Ambix

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THE SOCIETY FOR THE STUDY OF ALCHEMY AND EARLY CHEMISTRY

The Society for the Study of Alchemy and Early Chemistry has as its object the scientific and historical study of the subjects named in its title. The Society's journal, *Ambix*, is an indispensable means of research for those engaged in studies of these branches of the history of science. The membership subscription is £2 2s. 0d., and the subscription to non-Members, Libraries and Institutions, for one volume, is £2 12s. 6d., post free. All subscriptions should be sent to the Hon. Treasurer, Dr. W. A. SMEATON, Dept. of History and Philosophy of Science, University College, W.C.1. Applications for membership of the Society should be made to the Hon. Secretary, Dr. F. W. GIBBS, The Royal Institute of Chemistry, 30, Russell Square, London, W.C.1.

AMBIX

Articles of a scholarly and scientific nature are invited, and their scope may include any period in the history of alchemy and of chemistry up to the time of Dalton (*c.* 1808). While every care will be taken of authors' manuscripts, no responsibility will be accepted for accidental loss or damage.

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Vol. IX FEBRUARY, 1961 No. 1

JOSEPH PRIESTLEY AND THE COPLEY MEDAL

By Douglas McKie*

In Thorpe's biography of Priestley, it is stated that, after Priestley had published in 1772 his account of a method of making an artificial Pyrmont or aerated water[1], later called "soda-water", the Council of the Royal Society "were moved to reward its discoverer with the Copley Medal", and that "to-day the Copley Medal is regarded as the highest award which it is in the power of

* University College, London.

[1] In his *Directions for impregnating water with fixed air; in order to communicate to it the peculiar spirit and virtues of Pyrmont water, and other mineral waters of a similar nature* (London, 1772, iii + 22 pp.). The dedication of this pamphlet to the Earl of Sandwich, First Lord Commissioner of the Admiralty, was dated from Leeds 4 June, 1772: it was therefore published after Priestley had read to the Royal Society on 5, 12, 19 and 26 March, 1772, the first part of his famous memoir entitled "Observations on different kinds of air", for which he received in 1773 the Copley Medal for 1772. In the memoir Priestley mentioned, of course, his preparation of an artificial mineral water and also, as he was able to do since the memoir was printed much later, his pamphlet of *Directions*, but this was only one item in what would not be inaccurately described as a torrent of discoveries and experiments and observations; and Pringle referred to it in his address in the same way, as one of Priestley's many labours.

the Society to bestow, and certainly no man starts his scientific career by acquiring it—not even for so signal an invention as that of soda-water"[2]. This nonsense has often been repeated since Thorpe wrote these words; and a recent version, by Bernal, may be quoted to illustrate its persistence through fifty years: "Les expériences utilitaires étaient spécialement appréciées, comme le montre l'example de Priestley qui reçut la Médaille Copley, la plus haute récompense de la Royal Society, pour son invention de l'eau de Seltz, sur laquelle une industrie importante allait se fonder"[3].

The medal was presented to Priestley at the anniversary meeting of the Royal Society on 30 November, 1773, by the President, Sir John Pringle, and the third paragraph of the address delivered by the President on this occasion announced, not that Priestley was being so honoured for the invention of an artificial mineral water, but that this public mark of the Society's approbation was awarded to him "on account of the many curious and useful experiments contained in his *Observations on different kinds of Air*, read at the Society in March, 1772, and inserted in the last complete volume of your Transactions". In his address, Pringle naturally made incidental reference to Priestley's other work, but he made the grounds on which the medal was awarded adequately clear. Pringle's address is not widely accessible to all who are interested in the history of science; and for this reason and also because of its valuable survey of the study of air from the work of Boyle onwards, it is reproduced below in full.

GENTLEMEN,

It is with great satisfaction I enter upon this part of my office—to confer, in your name, the prize-medal of this year upon a Member of this Society so worthy of that distinction.

The object which Sir GODFREY COPLEY, founder of the benefaction, had in view, and in what manner the original pecuniary reward was converted into this more liberal form, having been so lately explained by my honoured predecessor; I need only observe, that though your President and Council have been entrusted with the sole power of adjudging this premium, yet they have now, as, I am persuaded, they have had on former occasions, the greatest solicitude to nominate that person, who, in their opinion, would have obtained all your suffrages.

[2] [Sir] T. E. Thorpe, *Joseph Priestley*, London, 1906, pp. 77–80. Thorpe's description of Priestley as starting his scientific career in 1772 is, to say the least, inexact. Before 1772 Priestley had already published five papers in the *Phil. Trans.*, two editions of his *Familiar introduction to electricity* (London, 1768 and 1769) and two editions of his *History and present state of electricity* (London, 1767 and 1769); and there had been an earlier proposal by Franklin in 1767 that the Copley Medal should be given to him for his electrical experiments (C. R. Weld, *A History of the Royal Society*, London, 1848, vol. ii, pp. 67–69).

[3] J. D. Bernal, *Rev. d'Hist. des Sciences et de leurs applications*, 1956, **9**, 294.

In confidence of this unanimity, it is with singular pleasure I acquaint you, that the Reverend JOSEPH PRIESTLEY, Doctor of Laws, has been found at this time the best entitled to this public mark of your approbation, on account of the many curious and useful experiments contained in his *Observations on different kinds of Air*, read at the Society in March 1772, and inserted in the last complete volume of your Transactions [*a*]. And indeed, GENTLEMEN, when you reflect on the zeal which our worthy brother has shewn to serve the public and to do credit to your institution, by his numerous, learned, and valuable communications, you will, I imagine, be inclined to think that we have been rather slow than precipitate in acknowledging so much merit.

Your time will not allow me to touch on the subjects of his former Papers [*b*]; nay I apprehend I shall even trespass upon it, by recalling to your memory only a few of those interesting discoveries which Doctor PRIESTLEY has made in these *Observations:* since in doing justice to others, as well as to him, it will be proper to remind you of the progress that had already been made in this part of science by men of the greatest abilities in their time, and by other ingenious persons still among us.

THERE is not perhaps any branch of Natural Philosophy that has more engaged the attention of the learned, or been more successfully cultivated, than the nature of the common air. The knowledge how indispensable it is to the preservation of animals, must have been coeval with mankind: it was from the beginning, as now, *the breath of life.* It was found likewise to be a necessary support of fire; and they saw that the vegetable creation, deprived of it, languished and died. Nor did the ancient physicians fail to distinguish, at least attempt to distinguish, between the effects of an air too hot and one too cold, an air too moist and one too dry, and between an insalutary and a wholesome air.—Thus far the experience, or the theory of all ages.—But the less obvious properties of this element, its gravitation and its elasticity, with their long train of consequences, remained unknown, till, about the beginning of the last century, Lord BACON and GALILEO, in that dawn of philosophy which they themselves diffused, began the inquiry. The former from experiments ascertained the elasticity of the air, and upon that principle constructed his *vitrum calendare*, the first thermometer [*c*]. The latter discovered that air had weight: but though that ornament of Italy was not ignorant of the limited suction of a pump, yet to account for the rise of the water so far in it, he still had recourse to Nature's *abhorrence of a void* [*d*].

TORRICELLI, at last, the disciple of GALILEO, by one happy and decisive experiment discovered the pressure of the atmosphere; and PASCAL observed, that this pressure varied according to the heights he carried his barometer [*e*]. Soon after followed the air-pump, the invention of the celebrated OTTO DE

[*a*] Vol. 62.

[*b*] In *Phil. Trans.*, vol. 58, 59, 60.

[*c*] *Bac. Nov. Org.*, lib. 2, aph. 13.

[*d*] Dialog. 1.

[*e*] Traité sur l'Equilibre des Liq.

GUERICK; which though at first a rude and imperfect instrument, yet improved by himself [*f*], and more by Mr. BOYLE and Dr. HOOK (two of the illustrious fathers of this Society) it soon became in the hands of Mr. BOYLE the means of opening the richest mines of natural knowledge. In this research, the History of the common air, he seemed so far to carry his inquiries, as to leave little to be done by others who should come after him; those parts excepted depending on geometry and calculation [*g*]. How successfully these were executed by Dr. HALLEY and Sir ISAAC NEWTON, I scarce need mention; nor the solid foundation on which those great men established the rarefaction of the air; and in what proportion, according to its distance from the earth [*h*]. But it was Sir ISAAC NEWTON alone, who, upon the principle of the air's being compressed by the power of gravity, and that of its elasticity, taught that tremulous bodies would communicate their motion to the air, and thereby excite vibrations in it, spreading every where. Thus he discovered the efficient cause of sounds [*i*].

But before this period Mr. BOYLE observing, as he himself informs us, how much air was concerned in many of the *phænomena* of Nature, and how necessary it was to the existence of animals, became solicitous to inquire, whether a fluid of so great importance were not produceable by art; if so, he believed that such air might be serviceable in life, particularly in the art of diving, and in *submarine navigation* [*k*]. With these views that admirable Naturalist set about making some new experiments, and from a variety of bodies, by different processes, obtained a pneumatical fluid (from ripe fruit, fermenting and effervescing liquors, and from the putrefaction of animal and vegetable substances) answering, till then, his only criterion of air, in being of a durable elastic nature [*l*]. Yet after all, Mr. BOYLE found that these new productions were essentially different from common air; as they presently extinguished flame, and suffocated those animals that attempted to breathe in them. But though he missed finding what he so much wanted, his labour was not in vain; philosophy was enriched with the knowledge of what he called *factitious* or *artificial* air, which has in the end proved as useful as he wished, in explaining several natural appearances, and in being subservient to the wants of man.

But this discovery, however interesting to the Naturalist, to the Chemist in particular [*m*], seems to have been little attended to, till in the beginning of this century Sir ISAAC NEWTON observed, that though true permanently elastic air arises from fixed bodies by heat and fermentation, and that though those aërial

[*f*] Gaspar. Schott. De Arte Mechan. Hydr. Pneumat. Exp. nova Magdeburg.

[*g*] Boyle, Physico-mechan. Exp. & Mem. for a Gen. Hist. of the Air.

[*h*] *Phil. Trans.*, No. 181, p. 104. Abrid. vol. 2, p. 14. *Phil. Nat. Princ. Math.*, lib. 2, prop. 22, 23.

[*i*] *Phil. Nat. Princ. Mat.*, lib. 2, prop. 43.

[*k*] An attempt of Cornelius Drebell to make a vessel to row under water with men in it. See Boyle's works, vol. 1, p. 69; vol. 3, p. 174.

[*l*] Boyle's Works, vol. 4, p. 206 and seq.

[*m*] *Hales Stat. Ess.*, vol. 1, ch. 6, p. 317.

particles recede from one another with the greatest repulsive force, yet they are brought again together; and that dense bodies by fermentation rarefy into several sorts of air, which without it returns into dense bodies [*n*]. Excited by such authority, the Reverend Doctor HALES (whose philosophic and amiable qualities are still fresh in the memories of several gentlemen present) resuming those experiments concerning the separation of air from bodies, confirmed and extended the discoveries of Mr. BOYLE; shewing not only that air entered into the composition of most bodies, but the very proportion it bore to the rest of the compound, and that often to an amazing quantity [*o*]. Dr. HALES likewise examined the mineral waters, especially those of Pyrmont, and finding them abounding with air, to that circumstance he ascribed the spirit and briskness of those fountains. But that excellent author did not seem to apprehend, that in this, as in other instances, the air which he produced was not the common air, but, if I may be allowed the expression, the *factitious* air of Nature; as being of the same sort with what Mr. BOYLE had extracted from fermenting and effervescing liquors; nay the same with the *mephitis* or deadly vapour of the ancients, or the *mofeta* of the modern Italians, so frequently met with in the caverns, springs, and lakes of their country: and the same with the *stith* or *choak-damp* in our coal-pits, so often fatal to the miners. It must be owned it was hard to conceive, how these springs should owe their prime virtues to what, in another manner of application, Dr. HALES saw was so destructive of vitality.

Now this notion concerning the impregnation of the mineral waters by the *mephitis*, was, as far as I know, originally suggested by a foreign Member, Dr. SEIP of Pyrmont, first in a treatise he published in the German language, and afterwards in a communication to this Society, in the year 1736, in which he describes a small cavern at Pyrmont, similar to the *grotta de' cani*, near Naples [*p*]. But when this ingenious author calls that *mephitis* (which is a durably elastic fluid *sui generis*) a *sulphureous steam*, or a *sulphureo-spirituous vapour*, he appears to have been imperfectly acquainted with its nature; which is now found to consist of nothing inflammable or sulphureous, and to be of a density or specific gravity considerably greater than that of common air.

Thus the fuller discovery of this principle we owe to Dr. BROWNRIGG of White-haven, who, about thirty years ago, began clearly to unfold this mystery. But those curious papers were not then inserted in the Transactions, as the too modest author had requested a delay, till he should be able to make them more worthy of that honour. In communication he remarks, "That a more intimate acquaintance with those noxious airs in mines, called *damps*, might lead to the discovery of that subtile principle of mineral waters, known by the name of their *spirit*; that the mephitic exhalations, termed the *choak-damp*, he had found to be a fluid permanently elastic; and from various experiments he had reason to conclude that it entered the composition of the waters of Pyrmont, Spa, and others; imparting to them that pungent taste, from which they were

[*n*] *Optics*, Quer. 31.

[*o*] *Stat. Ess.*, vol. 1, ch. 6.

[*p*] *Phil. Trans.*, No. 448, Abridg. vol. 8, p. 659.

denominated *acidulae*, and likewise that volatile principle, on which their virtues chiefly depend [*q*]".

In order to ascertain a fact of so much consequence, Dr. BROWNRIGG took the opportunity, when at Spa several years after, to make some experiments for this purpose; when he had the satisfaction to find those waters pregnant with the *artificial* or *factitious* air of Mr. BOYLE, the same with that of the suffocating *grotta* near Naples, and the same with the *choak-damp* of our coal mines; for as much as this air instantly extinguished flame, and the life of those animals he had inclosed in it [*r*]. The success of this worthy member, in thus far analyzing those waters, encouraged others to pursue the inquiry; and to investigate the manner in which Nature also furnished them with the chalybeate principle [*s*]. Mr. LANE therefore, in consequence of a conversation with Dr. WATSON junior (both of this Society) upon an experiment of Mr. CAVENDISH's, by which that gentleman had found the mephitic air (such as Dr. BROWNRIGG had detected in Spa-water) sufficient to dissolve any calcarious earth [*t*]: in consequence, I say, of this conversation, wherein it was surmised, that the same mephitic air might likewise dissolve iron in common water, Mr. LANE made the experiment with air taken from Spa water, and happily succeeded [*u*]. By this means the nature of the metallic principle in mineral waters was clearly explained; and the whole analysis of those celebrated fountains, so often attempted by Chemists and others, and still eluding their laboured researches, was thus in the most simple manner brought to light.

Nothing now seemed to be wanting to the triumph of Art, but an easy manner of joining, as there should be occasion, one or both of these principles to common water; in order to improve upon Nature, in the more extensive use of her medicine. This was effected by Dr. PRIESTLEY, after some other important discoveries had been made in this part of pneumatics, first by Dr. BLACK, Professor of Chemistry at Edinburgh, and then by Mr. CAVENDISH of this Society. The former has shewn that a particular species of factitious air (he calls it *fixed*) adheres to all calcarious earths, magnesia, and alcaline salts, with different degrees of force; and that this fluid can be separated from these substances, and combined again with them, in the same manner as an acid. Upon this discovery he explained in a clear and simple manner many appearances in Chemistry, till then deemed the most unaccountable. Such was the effervescence of absorbent earths and alkaline salts with acids, and the change of the mild calcarious earths into quick lime by heat (in consequence of the expulsion of this *fixed* air which neutralizes them) [*w*]. I must add, that I have been well informed, that for several years past the learned Professor has taught, that the air which unites with alkaline substances is of the same nature

[*q*] *Vid. Phil. Trans.*, vol. 55, p. 236, & seq.

[*r*] *Ib.*, p. 218 & seq.

[*s*] More properly, the *iron-principle*.

[*t*] *Phil. Trans.*, vol. 57, p. 92 & seq.

[*u*] *Ib.*, vol. 59, p. 216 & seq.

[*w*] *Ess. and Observ. Phys. & Liter*, vol. 2, p. 157 & seq.

with the *mephitis*, or suffocating air of the *grotta de' cani* and mines; the same with what is emitted from vegetables in fermentation; and that in some respects it agrees with the air which has been injured by the breath of animals, or by the burning of fuel: and lastly, that the air or elastic fluid arising from the solution of metals by acids is very different from the former.

Mr. CAVENDISH has made several valuable additions to these discoveries, not only with regard to that species of *factitious* air the Professor had denominated *fixed air*, but to other elastic fluids. He has with accuracy ascertained the specific gravity of this fixed air, as expelled from alkaline substances by acids, or from vegetable matter by fermentation; and has demonstrated the similarity of airs produced by either of these two ways. He has confirmed Dr. BLACK's account of the quantity of the fixed air contained in alkaline salts and in alkaline earths. He has shewn that this fluid can be mixed with water, and in what proportion; and that it flies off again from the water upon heating it, or exposing it to the common air. Lastly, that this species of factitious air imparts to the water the power of dissolving absorbent earths; the experiment, as I observed before, which led to the knowledge, how Nature infused the metallic principle into what are commonly called the *chalybeate waters* [*x*].

Of all these facts Dr. PRIESTLEY has carefully availed himself. For having learned from Dr. BLACK that this fixed or mephitic air could in great abundance be procured from chalk, by means of diluted spirit of vitriol [*y*]; from Dr. MACBRIDE, that this fluid was of a considerable antiseptic nature [*z*]; from Mr. CAVENDISH, that it could in a large quantity be absorbed by water [*a*]; and from Dr. BROWNRIGG, that it was this very air which gave the briskness and chief virtues to the Spa and Pyrmont waters [*b*]: Dr. PRIESTLEY, I say, so well instructed, conceived that common water impregnated with this fluid alone might be useful in medicine, particularly for Sailors on long voyages, for curing or preventing the Sea-scurvy. This, we know, is a putrid distemper requiring all the antiseptic quality of those mineral waters, without the chalybeate principle, which might injure by over-heating the blood, too much disposed to inflammation. For this purpose he made a simple apparatus for generating this species of air from chalk and mixing it with water, in such quantities, and in so speedy a manner, that having exhibited the experiment before this Society and the College of Physicians, it met with so much approbation, that, in order that the Public might the sooner reap the benefit of it, he was induced to detach this part of his labours, and in a separate Paper to present it to the Admiralty [*c*].

The rest of his observations upon the different kinds of air, addressed to the Society [*d*], contain so much matter, that I will not presume to encroach so

[*x*] *Phil. Trans.*, vol. 56, p. 141 & seq.

[*y*] *Ess. and Observ. Phys. & Liter, loc. cit.*

[*z*] Experim. Ess. *passim*.

[*a*] *Phil. Trans.*, vol. 56, p. 161 & seq.

[*b*] *Phil. Trans.*, vol. 55, p. 218 & seq.

[*c*] A pamphlet intituled Directions for impregnating water, &c.

[*d*] *Phil. Trans.*, vol. 62.

far on your time, as to offer even a short abstract of the whole; but shall be satisfied to single out a few of those many discoveries, such as are the most striking, either for their immediate use in life, like that above; or for the explanation of some of the more interesting appearances in Nature.

I come therefore to another species of *factitious* air, called the *inflammable*. Till within these few years little more was known, than that this kind of subtile fluid was found in mines, in neglected privies and common sewers; but chiefly in coal-pits, where it is called the *fire-damp*, making sometimes formidable explosions, and indeed often fatal to the miners. I do not recollect that Mr. BOYLE has taken any other notice of it [*e*]. But about 40 years ago Sir JAMES LOWTHER Baronet, favoured the Society with an account somewhat more particular of this production of his coal-mines in Cumberland, accompanying it with several bladders filled with that fluid, which in this house burnt as readily, as at its source a month before. Yet still this extraordinary substance was considered more as an object of curiosity, than as one of philosophical inquiry, till Mr. CAVENDISH began to make experiments upon it; by which, and the consequences drawn from them, he has added another considerable branch to the doctrine of aërial fluids.

First, he has taught how to produce at will, and in great abundance, this other permanently elastic fluid from three metallic bodies, Zinc, Iron, and Tin, by dissolving them in the diluted vitriolic acid, or spirit of sea-salt. This species of factitious air he has shewn to be surprizingly light, being no more than the tenth part of the weight of common air, and therefore totally different from the *mephitis*, that other species of factitious air we have been treating of, and which, as was observed, is heavier than the air of our atmosphere. Lastly Mr. CAVENDISH has given several experiments upon the inflammability of various mixtures of this fluid with common air, which are likewise new; and, like the rest, have been made with great precision.

Now, though Dr. PRIESTLEY has also improved upon this inquiry, by the addition of a variety of experiments; in particular, by shewing how this air becomes miscible with water, and deprived of its inflammability; by comparing it with other species of factitious air, in regard to conducting the electrical fluid; by inquiring how far it may be considered as common air loaded with the principle of fire, called *phlogiston* by the modern Chemists; with other curious observations on this substance: yet all these, with other kinds of factitious air, as I have already too long detained you, I must with regret pass over; one other species excepted, as I reckon it among the most brilliant of Dr. PRIESTLEY's discoveries [*f*].

This species he called the *nitrous air*, without insisting on the propriety of the expression. It was first produced from the Walton pyrites by means of the

[*e*] Boyle's Works, vol. 3, p. 101; vol. 5, p. 305, 306.

[*f*] I might have added another new species of factitious air, which he terms *acid*, first taken notice of by Mr. CAVENDISH, and more fully investigated by Dr. PRIESTLEY. This is an elastic vapour expelled by heat from spirit of salt, and not liable afterwards to be condensed by cold. Water readily imbibes this air, and by that means becomes a strong spirit of salt. The same acid air or vapour, he has also discovered to be a decomposer of substances that contain *phlogiston*, and with them to form a proper inflammable air.

spirit of nitre. Dr. HALES, who made the experiment, observed, that when joined to common air, an effervescence ensued, with a turbid red colour of the mixture, and an absorption of part of the common air [*g*]. Dr. PRIESTLEY extending the experiment to other metallic substances observed, that the same kind of air was by the same acid readily procured from iron, copper, brass, tin, silver, quicksilver, bismuth, and nickel; and that though it constantly, when joined to common air, exhibited those appearances mentioned by Dr. HALES, and more conspicuously in proportion to the purity of the common air mixed with it (that is, its fitness for respiration); yet it made no change with either fixed or inflammable air, or that air tainted by the breath of animals, or the corruption of their bodies. By means of this test he was enabled to judge of the kind, as well as of the degree of injury, done to common air by candles burning in it; and to perceive a real difference in the air of his study, after a few persons had been with him there. Nay, a phial of air having been sent him from the neighbourhood of a large town, it appeared upon a comparative trial to be inferior in quality to that taken up near Leeds, where he then resided. It was upon such a prospect of obtaining a criterion for distinguishing good air from bad, that Lord BACON almost in a rapture breaks out: "These are noble experiments that can make this discovery; for they serve for a natural divination of seasons!" and again, "They teach men to choose their dwelling for their better health [*h*]".

Nor is this all the use of the nitrous air; Dr. PRIESTLEY shews it to be one of the strongest antiseptics. The fixed air has been proved by Dr. MACBRIDE, as was remarked, to be powerful in this particular; but this species of factitious air has been found to be of superior efficacy. And as our author has discovered it to be miscible with water, he has reason to believe it may be applied to various purposes, such as the preservation of the more delicate birds, fishes, fruits, and anatomical preparations.

I shall now conclude with shewing from Dr. PRIESTLEY, what resources Nature has in store against the bad effects of corrupted air, which from various causes infect our atmosphere.

It is well known that flame cannot long subsist without a renewal of common air. The quantity of that fluid which even a small flame requires is surprizing: an ordinary candle *consumes*, as it is called, about a gallon of air in a minute. Now, considering the vast consumption of this vital fluid by fires of all kinds made by man, and by volcanos, it becomes an interesting inquiry, to ascertain what change is made in the air by flame; and to discover what provision there is in Nature, to repair the injury done by this means to our atmosphere. Dr. PRIESTLEY, after relating the conjectures of others, and not finding them satisfactory, was fortunate in falling upon a method of restoring air, which had been vitiated by the burning of candles in it. This led the way to the discovery of one of the great restoratives which Nature employs for this purpose; to wit, vegetation: see by what induction he proves his opinion.

It was natural to imagine, that since the change of common air is necessary to vegetable, as well as to animal life, both plants and animals rendered it

[*g*] *Stat. Ess.*, vol. 2, p. 280.

[*h*] Nat. Hist. Exp. 777.

foul in the same manner, so as to become unfit for further life and vegetation. But when with that expectation the Doctor had put a sprig of mint, in a growing and vigorous state, under an inverted glass-jar standing in water, he was agreeably disappointed to find, that this plant not only continued to live, though in a languishing way, for two months, but that the confined air was so little corrupted by what had issued from the mint, that it would neither extinguish a candle, nor kill a small animal which he conveyed into it. What further evinced the salutary nature of the *effluvia* of vegetables; he found, that air vitiated by a candle left in it till it burnt out, was perfectly restored to its quality of supporting flame, after another sprig of mint had for some time vegetated in it. And to shew that the aromatic vapour of that plant had no share in restoring this purity to the air, he observed, that vegetables of an offensive smell, and even such as scarce had any smell at all, but were of a quick growth, proved the very best for this purpose. Nay more, the virtue of growing vegetables was found to be an antidote to the baneful quality of air corrupted by animal respiration and putrefaction.

We have said, that neither candles will burn nor animals live beyond a certain time in a given quantity of air; yet the cause of either so speedy a death or extinction was unknown; nor was any method discovered for rendering that empoisoned air fit again for respiration. Some provision however there must be in Nature for this purpose, as well as for that of supporting flame: without such the whole atmosphere would in time become unfit for animal life, and the race of men as well as beasts would die of a pestilential distemper. Yet we have reason to believe, that in our day the air is not less proper for breathing in, than it was above two thousand years ago; that is, as far as we go back in Natural History. Now, for this important end, the Doctor has suggested, to the Divine as well as to the Philosopher, two grand resources of Nature: the vegetable creation again is one, and the sea and other great bodies of water are the other.

As to the former, having found that plants wonderfully thrive in putrid air, he began to attempt by means of growing vegetables to purify air that had been injured by animal respiration and putrefaction; nor was he less successful than before. These plants were sure to recover the air to a degree of fitness for breathing in it, and that in proportion to their vigour, and the care he took to remove the rotten leaves and branches; which remaining would have marred the operation.

And with regard to the second resource of Nature, namely the ocean and other waters, Dr. PRIESTLEY having observed, that both the air corrupted by the breath of animals, and that vitiated by other putrid matter, was in a good measure sweetened by the septic part infusing itself into water, he concluded, that the sea, the great lakes and rivers, which cover so large a proportion of the globe, must be highly useful, by absorbing what is putrid, for the further purification of the atmosphere: thus bestowing what would be noxious to man and other animals, upon the formation of marine and other aquatic plants, or upon other purposes yet unknown.

From these discoveries we are assured, that no vegetable grows in vain, but that from the oak of the forest to the grass of the field, every individual plant is serviceable to mankind; if not always distinguished by some private

virtue, yet making a part of the whole which cleanses and purifies our atmosphere. In this the fragrant rose and deadly nightshade co-operate: nor is the herbage, nor the woods that flourish in the most remote and unpeopled regions unprofitable to us, nor we to them; considering how constantly the winds convey to them our vitiated air, for our relief, and for their nourishment. And if ever these salutary gales rise to storms and hurricanes, let us still trace and revere the ways of a beneficent Being; who not fortuitously but with design, not in wrath but in mercy, thus shakes the waters and the air together, to bury in the deep those putrid and pestilential *effluvia*, which the vegetables upon the face of the earth had been insufficient to consume.

THIS, GENTLEMEN, is what I had to say upon the occasion: perhaps too much; but the fruitfulness of the subject, with my earnest desire of commemorating some of the more important experiments and conclusions of Dr. PRIESTLEY and of those who preceded him in these inquiries, will, I hope, plead my excuse. Nor can I conclude without congratulating this illustrious Body on the possession of so many members and friends, so capable to promote the great ends of this institution; and who have within these few years so eminently distinguished themselves, by the lights they have thrown, not only upon this, but upon other of the more subtile fluids of Nature. You will understand, that to these discoveries upon factitious air, I join those amazing ones upon magnetism and electricity, with all the uses resulting from them. Here you will recollect the prediction of him, who best taught the method of investigating philosophical truth, the incomparable Lord BACON, who, with that spirit of divination peculiar to exalted genius, assured his disciples, that when men should cease to trifle in framing *hypotheses*, and building hasty systems; and should by a proper induction from sober and severe experiments attain to the knowledge of the *forms* of things [their more intimate qualities and laws] they should in the end command Nature, and perform works as much greater than were supposed practicable by the powers of natural magic, as the real actions of a *Cæsar* surpassed the fictitious ones of the hero of a romance [*i*]. Some earnest, nor that inconsiderable, of this magnificent promise this Society has already obtained. Let those who doubt, view that Needle, which, untouched by any loadstone, directs the course of the British mariner round the world; or that apparatus, so perfectly imitating the long supposed inimitable lightning; or that other, which disarms the clouds of that tremendous meteor: or (not to depart from my subject) let them see how Art can from chalk only, the least promising substance, generate, or call it unfetter a copious elastic fluid imprisoned in it, the poison of man, or his medicine, according to the mode of application; which, though invisible, yet dissolves earth and metals, and imparts the spirit and virtue to the most prized of mineral waters. Yet these are but inventions of yesterday: I would strictly say, inventions within the memory of my youngest hearer. If to these late acquisitions, so honourable to this Society, I add those in Natural History, by the zeal and unwearied attention of some worthy members, who have extended your correspondence and adorned your Museum; and by those other gentlemen, who, animated by a noble spirit, have, to their lasting honour, undertaken the most dangerous and most distant

[*i*] Compare Bac. De Dignit. et Augment. Scient., lib. 3, cap. 5.

voyages in pursuit of Natural Knowledge: I say, when to the progress you are making in Experimental Philosophy, I add that in the History of Nature, every true lover of science will rejoice to think, that your affairs have not, perhaps, at any period, been in a more flourishing condition.

Dr. PRIESTLEY,

It is now time that, in the name and by the authority of the Royal Society of London, instituted for the improvement of Natural Knowledge, I present you with this medal, the palm and laurel of this Community; as a faithful and unfading testimonial of their regard, and of the just sense they have of your merit, and of the persevering industry with which you have promoted the views, and thereby the honour of this Society. And in their behalf I must earnestly request you, to continue those liberal and valuable inquiries, whether by further prosecuting this subject, probably not yet exhausted, or by investigating the nature of some other of the subtile fluids of the universe. You will remember, that *Fire*, the great instrument of the Chemists, is but little known even to themselves; and that it remains a *Query*, what was by the most celebrated of philosophers proposed as such, whether there be not a certain fluid (he calls it *Æther*) the cause of gravity, the cause of the various attractions, and of the animal and vital motions [*k*]. These, Sir, are indeed large demands: but the Royal Society have hitherto been fortunate in their pneumatic researches. And were it otherwise, they have much to hope from men of your talents and application, and whose past labours have been crowned with so much success.

* * * * *

Originally Sir Godfrey Copley's legacy, received by the Royal Society in 1709, provided an annual "donation" for an experiment made before the Society, but on 7 December 1736, by resolution of Council, the "donation" was converted into a medal for "the best Experiment produced within the Yr"[4]. The Council Minutes of the Society show that in 1766 there was a feeling that awards of the medal had been delayed for some years, and at the meeting of Council held on 24 November, 1766, it was recorded:

> "It was proposed by the President, & resolved by Ballot as the Medals for divers years past, have not been disposed of: and there have been divers papers of Note within that time; that on S^{t} Andrews day next three Medals be bestowed as follows viz to Edward Delaval Esq^{r} F.R S for his Experiments and Observations on the Agreement between the specific gravities of the several Metals, and their Colours when United to Glass, as well as those of their other Preparations. To William Brownrigg M D F R S for an Experimental Enquiry into the Mineral Elastic Spirit, or Air contained in Spaa Water; as well as into the Mephitic Qualities of this Spirit; and to the Hon^{ble} Henry Cavendish Esq^{r} F R S for his late curious Experiments on Factitious Air"[5].

[*k*] Newton's Optics, Quer. 18–24.

[4] Minutes of Council, vol. iii, p. 175.

[5] *Ibid.*, vol. v, p. 153.

Following this decision, Council further recorded at a meeting on 27 November, three days later:

> "The strong box was opened, and the three Medals Ordered at the last Council, were taken out, and the Names of the respective three Gentlemen ordered to be engraved thereon; and the President was requested to deliver them on S[t] Andrews day next. On this Occasion it appeared that the Medals now remaining in the strong box, are eight in Number"[6].

It will be observed that two of the three awards, those to Dr. Brownrigg and the Hon. Henry Cavendish, were given for experiments on air.

A year later, on 26 November, 1767, it was evidently thought that Priestley should be considered for the award that would shortly fall due, and the minutes of the meeting held on that day include the following:

> "It was moved and Resolved Unanimously that the Merits of D[r] Priestley's Book[7] be now taken into Consideration with a view to any reward of his Merits as far as relates to the power of the Council in the adjudication of Sir Godfrey Copley's Medal to the best Experiment of the year.
>
> "An account of the said Book, by D[r] Benjamin Franklin, was read for the information of the Council"[8].

There seems, however, to have been some difficulty about the interpretation of the terms of the relevant clause in Sir Godfrey Copley's will, because, at this same meeting of 26 November, 1767, a further minute recorded: "Ordered, that an Extract from Sir Godfrey Copley's Will, relative to his Legacy to the Society, be had from the Commons, and laid before the Council"[9].

A fortnight later, on 10 December, an extract from Sir Godfrey's will was read to the effect that the sum of one hundred pounds in trust for the Society was "to be laid out in Experiments or otherwise for the benefit thereof, as they shall direct or appoint"[10]. No further action seems to have been taken and for some reason or other Priestley's work appears to have been considered by Council as not rendering him eligible for the award; and no award was made on this occasion. A letter from Franklin to Canton[11], written on this matter,

[6] *Ibid.*, p. 155.

[7] *The History and Present State of Electricity*, London, 1767.

[8] Minutes of Council, vol. v, p. 179.

[9] *Ibid.*, pp. 179–180.

[10] *Ibid.*, p. 201.

[11] C. R. Weld, *op. cit.*, vol. ii, pp. 67–69.

although it suggests some opposition to the proposal to award the medal to Priestley, makes it clear not only that the medal should be given for experiments proposed and directed by the Society and made in their presence, but also that most of the recent awards had not complied with this condition. The situation would seem also to the modern reader to have been further complicated by the circumstance that Priestley's experiments had been published independently in one of his books and not communicated to the Society or published in their *Philosophical Transactions*. According to Franklin's letter it was intended to award the medal to Priestley at the next meeting, if Council thought fit and if it were found to be not contrary to Sir Godfrey Copley's will to do so: but the award was not made, and, in the absence of any recorded reason in the minutes, it is therefore not inappropriate to conclude that Council appears to have found that the proposed award would have infringed the terms of the will.

In the following year, at the meeting of 17 November, 1768, the minutes record that "The Council took into consideration the disposal of the annual Medal" for 1767 and for 1768; the medal for 1767 was awarded to John Ellis for his work in natural history and that for 1768 to Peter Woulfe for his experiments on the distillation of acids, alkalis, etc.[12] Since a year previously, after resolving unanimously to consider Priestley for the medal, Council had not awarded it at all, these two further decisions to confer it on others support the view expressed above that on 10 December, 1767, Council had concluded, after the unanimous resolution of 26 November, 1767, in Priestley's favour, that he was not eligible for it.

During the next three years the medals for 1769, 1770 and 1771 were awarded respectively to William Hewson, Sir William Hamilton and Matthew Raper[13].

Then on 11 November, 1773, Council considered the award for 1772. There were present: the President, Sir John Pringle, and "Hon: Daines Barrington, Hon: Henry Cavendish, D^{r} Franklin, Rev^{d} M^{r} Horsley, Rev^{d} M^{r} Maskelyne, D^{r} Maty, D^{r} Morris, D^{r} Morton, W^{m} Mountaine Esq, Rev^{d} D^{r} Price, Matthew Raper Esq, D^{r} Watson, Sam^{l} Wegg, Rev^{d} M^{r} Wollaston". Among them were five Copley Medallists (Pringle, Cavendish, Franklin, Raper and Watson) The minutes read:

> "The President proposed the consideration of the disposal of Sir Godfrey Copley's medal for the year 1772, when the list of the papers printed for the said year being considered, it was moved and seconded,

[12] **Minutes of Council, vol. v, p. 337.**

[13] *Ibid.*, vol. vi, pp. 85, 116, 153.

> and resolved by ballot unanimously, that the medal for the said year be given to the Rev[d] Joseph Priestley L.L.D. for his various Philosophical publications; and particularly for his disquisition concerning the different kinds of Air; and the Medal was accordingly directed to be taken out of the Iron chest, and D[r] Priestley's name and the usual inscription ordered to be engraved upon it: And the President was desired to deliver it as usual on S[t] Andrews day next"[14].

The proceedings at the anniversary meeting on 30 November, 1773, are described in the Journal Book:

> "The President also acquainted the Society that the Council had adjudged the Medal of Sir Godfrey Copley for the year 1772 to the Rev[d] D[r] Priestley F.R.S. in consideration of his curious experiments on different kinds of air, and had requested him to present the same to D[r] Priestley, in their name, at this anniversary Meeting. On which occasion the President addressed the Society and D[r] Priestley in the following terms"[15].

Here follows in the Journal Book in manuscript a transcription of Pringle's address. At the end of the meeting the Journal records: "Thanks were returned to the President for this very able, and elegant Speech; and it was ordered unanimously that it be entered on the minutes of the Society"[16]. Pringle's lengthy and detailed address was, however, an innovation and it appears to have made a considerable impression on his audience; for, at the next meeting on 9 December, 1773, the Journal Book records:

> "On a motion made and properly seconded, it was unanimously ordered that the President be requested to permit that the Speech, which he made on delivering the Medal of Sir Godfrey Copley Bart. to the Rev[d] Joseph Priestley L.L.D. be printed"[17].

The address was duly published in 1774 under the title of *A Discourse on the different kinds of air, delivered at the anniversary meeting of the Royal Society, November 30, 1773. By Sir John Pringle Bart. President. Published at their request. London: Printed for the Royal Society. MDCCLXXIV.* This text, which we shall refer to below as (iii), is not, however, the only version: a copy of it in the possession of the Royal Society is bound at the end of volume 63 (1773) of the Society's set of the *Philosophical Transactions.* The original

[14] *Ibid.*, pp. 190–191.

[15] Journal Book, vol. xxviii, p. 205. Priestley's name is misspelt "Priestly" throughout this entry in the Journal Book.

[16] *Ibid.*, p. 231.

[17] *Ibid.*, pp. 233–234.

MS. of the address does not appear to be extant in the Society's archives, but there seem to be at least five slightly different versions of it: (i) a transcript, presumably from the author's MS., in the original Journal Book of the Royal Society in the record of the meeting of 30 November, 1773; (ii) a printed version bound in the copy of the Journal Book adjoining the entry for that date; (iii) the version mentioned above; (iv) a version bound with another set of the *Philosophical Transactions*; and (v) a reprint in Kippis's *Six Discourses* (London, 1783). These all differ in minor textual details and, of course, there have been numerous corrections of the text of (i) in the printed versions, of which (ii) may have been a proof or an early printing as (iii), the copy bound with the Royal Society's set of the *Philosophical Transactions*, seems to be definitive. There are various minor differences again in (iv) and (v). The text reproduced above is taken from (iii) with corrections from the *Errata* given for that version and others.

These matters apart, it will, however, be clear that Priestley received the Copley Medal, not for the invention of "soda-water", but in the words of the official citation by the President of the Royal Society "on account of the many curious and useful experiments contained in his *Observations on different kinds of Air*, read at the Society in March 1772, and inserted in the last complete volume of your Transactions".

* * * * *

Pringle, who by some curious error credited Francis Bacon with the construction of the first thermometer, said in his address that he could not within the time at his disposal give even a short summary of Priestley's "observations upon the different kinds of air, addressed to the Society", but that he would be satisfied with naming some of the most striking of them. He then referred especially to Priestley's work on "nitrous air" (nitric oxide) as among "the most brilliant" of his discoveries, although, he went on to say, he could have added "acid air" (hydrogen chloride). He drew special attention to Priestley's method of using "nitrous air" to measure the purity, or fitness for respiration, of common air; and he emphasized even more strongly Priestley's discovery of the part played by vegetation and by the seas in restoring air that had been corrupted by combustion, respiration and putrefaction.

Although Pringle stated that Priestley's work published in volume 62 of the *Philosophical Transactions* had been read to the Society in March, 1772, and although this classic memoir in pneumatic chemistry carries on its first page the rubric "Read March 5, 12, 19, 26, 1772", the attentive reader will observe that experiments and observations with later dates are included in it, especially a number relating to the restoration of vitiated air by plants. It seemed,

therefore, useful to compare the printed text with the original manuscript of the paper preserved in the Archives of the Royal Society[18]. The foliation of this document is curious and at once suggests that there have been additions; it runs at first from fol. 1 to fol. 54, then from fol. 55 to fol. 68, then from fol. 66 (a second sheet so numbered) to fol. 73, which is followed by fol. 73* and is then continued to fol. 81[19], but at this point there is another fol. 76 and so on to the last sheet fol. 97.

The printed paper (*Phil. Trans.*, 1772, **62**, 147–264) is arranged, after a short introduction (pp. 147–8) of two paragraphs, in ten sections as follows: I (not numbered), "Of Fixed Air" (pp. 148–162); II, "On Air in which a Candle, or Brimstone, has burned out" (pp. 162–170); III, "Of Inflammable Air" (pp. 170–181); IV, "Of Air infected with Animal Respiration, or Putrefaction" (pp. 181–207); V, "Of air in which a Mixture of Brimstone and Filings of Iron has stood" (pp. 207–209); VI, "Of Nitrous Air" (pp. 210–224); VII, "Of Air infected with the Fumes of Burning Charcoal" (pp. 225–227); VIII, "Of the Effect of the Calcination of Metals, and of the Effluvia of Paint made with White-lead and Oil, on Air" (pp. 228–234); IX, "Of Air procured by Means of Spirit of Salt" (pp. 234–244); X, "Miscellaneous Observations" (pp. 244–252). These sections are followed by an "Appendix" (pp. 253–256), containing an account of some experiments made by William Hey of Leeds, a letter from Hey to Priestley (pp. 257–264) and a "Correction" by Priestley relating to Hales's measurements of the diminution of air by respiration (p. 264). The paper was accompanied by a folding-plate showing Priestley's apparatus described (pp. 250–252) in detail in Section X.

Collation of the manuscript and the printed paper shows that there are differences here and there. For instance, on p. 156, lines 1–4 of the paper, with the exception of the first two words, do not seem to be in the manuscript; on p. 187, line 10 from foot, there is a change in the phrasing of a sentence; and it is probable that, in line 1 of p. 193 of the printed paper, the word "infected" has been printed in error for the correct "infested" on fol. 40 of the manuscript. On fol. 52 in the last few lines (end of Section IV on p. 207 of the printed paper), a sentence referring to Dr. Perceval's observations on Mr. Hey's administration of "fixed air" has been omitted from the printed version. On p. 211, line 15, of the printed paper, the words "and the regulus of antimony" have been added: they do not occur in the manuscript: and on p. 219, lines 19–21, the sentence reading "This I suppose to be a precipitate of the metal by the solution of which the nitrous air was generated" (obviously an addition, as

[18] Archives, Royal Society, Letters and Papers, Decade V, No. 284.

[19] At foot of fol. 81v. is written "Page 76 to follow this".

will appear later, because of the mention of "nitrous air") has been put in place of the original on fol. 63 reading "What this deposit is I cannot tell, but shall send a quantity of it for the inspection of the society". On p. 225, line 10 from foot, "burning" has been deleted from fol. 66 preceding the word "charcoal"; and on p. 233 in the first line of the second paragraph the word "improbable" has replaced the "impossible" (fol. 73) of the manuscript. Another change occurs on p. 235, lines 13 and 14 from foot: "a small quantity" has been put in place of "the quantity of two or three drops" in the original (fol. 74). On p. 245, line 13, the words "but in this even a candle" have replaced "in both of which, not only did a mouse live perfectly well, but even a candle" (fol. 77). Two pages later (p. 247, line 5 from foot) "a little extraordinary" has been put instead of the "very extraordinary" of the original (fol. 79).

As for additions to the manuscript, fol. 20 and fol. 21 seem to have been inserted: these correspond to pp. 168–170 of the printed paper from the last three lines on p. 168 to the end of Section II on p. 170, and they refer to experiments on the restoration of air by plants made from May to July, 1772, and therefore later than the reading of the paper to the Royal Society in March of that year. A similar addition on the same topic occurs as an insertion on the verso of fol. 23: it appears in the paper as the first complete paragraph on p. 174 and refers to an observation made on 19 June, 1772, again later than the reading of the paper in March. Then there seems to be a further addition, fol. 28, fol. 29 and fol. 30, relating to experiments made in July, 1772, and corresponding to pp. 179 (paragraph beginning on line 4) to 181 (end of Section III) of the paper; and, as will appear below, the Sections from VI to X (inclusive), at least 40 pages of the paper, embody observations and experiments made and communicated to the Royal Society later than March, 1772.

Almost the whole of the manuscript is in a hand other than Priestley's, but many of the additions have been written by him; these are generally short; the two most extensive occur on fol. 12 (p. 160, lines 7–32, of the paper, from "This I have" to "whether they") and on fol. 73 and fol. 73* (pp. 233–234 of the paper, from "That plants restore" to "parts of the solid"). None of these gives any indication of the date of addition.

The first section is marked in the manuscript (fol. 1) "Read March 5 1772"; the second is marked "March 12. 1772" (fol. 15) and the fourth "March 19. 1772" (fol. 31); and the fifth is marked "Read March 26. 1772" (fol. 53). Then, after a mere two sheets, the sixth section is marked "Read Nov. 26. 1772" (fol. 55).

The Journal Book of the Royal Society shows that the paper was read in parts on 5, 12, 19 and 26 March, 1772[20], the entry for the last date giving a

[20] Journal Book, vol. xxvii, pp. 591, 594, 596, 604.

summary[21] of what had been read at these four meetings, the Secretary rightly recording: "It would exceed the bounds of a minute, to recite the numerou particular experiments of this curious paper. I shall therefore confine myself to some of the principal results, as properties of the several kinds of Air investigated by the Author"[22]. The minute includes the statement that the paper, as read on these dates in March, 1772, consisted of six sections, as follows:

"1st. Of Fixed Air
2d. Of Air in which a candle or brimstone has burned out
3d. Of inflammable Air
4th. Of Air infected with animal respiration, or putrefaction
5th. Of Air in which a mixture of brimstone and filings of iron has stood
6th. Miscellaneous observations",

and, lastly, "a description of the Apparatus with which the principal experiments were made". Since the sixth section on "Miscellaneous observations" is in the final printing not very extensive (pp. 244–250, excluding the description of the apparatus: fol. 76 to fol. 81 in the manuscript) and since it contains some observations dated September and November, 1772, as well as references to the test of "nitrous air", it cannot have been very considerable when read in its first form on 26 March, 1772.

The most interesting detail about this manuscript is, therefore, not the many additions about experiments and observations dated later than March, 1772, but the entry opposite Section VI, "Of Nitrous Air": "Read Nov. 26. 1772". As has been noted already, the printed paper is described in the rubric to the first paragraph (p. 147) as "Read March 5, 12, 19, 26, 1772" and there is no mention there or elsewhere in it or in Pringle's address that any section of it, large or small, was read at any later date. The question immediately arises of how much of it was read at the later date, since there are no other such datings in the later pages of the manuscript; it would seem that the mention of the "test" of "nitrous air" shows that any part of the text containing it is an addition to the original version. A further interesting addition of four words, "or in nitrous air", at the end of the first complete paragraph of p. 182 of the printed paper bears on the same point to be discussed below. Then on fol. 42 (p. 194 of the paper, paragraph beginning line 4 from foot) there begins a long addition, marked "B" in the manuscript, and it is difficult to judge where it ends. The dates given ("in the summer of the year 1772" and so on) show

[21] *Ibid.*, pp. 604–612.

[22] *Ibid.*, p. 605.

clearly that it is an addition. This added matter may go on to fol. 48 (p. 202, line 2, of the printed paper). Apart from the evidence of dates and the mention of "nitrous air" in several places, there is a further indication that this large section (fols. 42–48) is an addition in that fol. 48 is a short page only partly written on. It might be added here that fol. 21 and fol. 30 are similarly short pages incompletely filled.

The entry in the Journal Book for 26 November, 1772, records: "A paper concerning Nitrous Air, being an Addition to a former paper concerning various kinds of factitious air, by the Rev^{d} D^{r} Priestley, F.R.S., was read"[23]. A summary of the paper as read then follows[24] and it is stated: "The paper contains divers other curious particulars, and results from experiments, which may rather be excused in this minute, as the Author is now printing the whole for the information of the Publick. A postscript accompanied the paper containing an account of some experiments made by Mr. Hey, which prove that there is no oil of vitriol in water impregnated with fixed Air, extracted from chalk by oil of vitriol"[25].

It therefore appears from the minutes in the Journal Book that only Sections I to V on Priestley's classic paper of 1772 and part of the original Section VI, later Section X, on "Miscellaneous observations", together with the description of the apparatus used, were read in March, 1772. The new Section VI (on "nitrous air") together with Sections VII (on air infected with the fumes of burning charcoal), VIII (on the effect on air of the calcination of metals, etc.), and IX (on air from "spirit of salt"), together with much of Section X on miscellaneous observations were read, not in March but late in November, 1772. Most important for the historian is the conclusion that Priestley's work on "nitrous air" and his application of it to measure the purity of air, or its fitness for respiration[26], and also his isolation and recognition of "acid air" (hydrogen chloride) are to be dated, not as of March, 1772, but in the months following and as having been first announced to the Royal Society on 26 November, 1772. Priestley had also at this later date announced his isolation of what he afterwards called "diminished nitrous air" (nitrous oxide) by the action on "nitrous air" (nitric oxide) of a mixture of iron filings and sulphur made into a paste with water.

[23] *Ibid.*, p. 673.

[24] *Ibid.*, pp. 673–677 (mispaged 678).

[25] *Ibid.*, pp. 676–677.

[26] Priestley had previously estimated the "goodness" of air by observing how long a mouse would live in it, but the method was slow and it was also unreliable because two mice would give different results in the same air; and he had to keep a large stock of mice.

As a final note to these details, it may be pointed out that, since only the first five sections of this famous memoir by Priestley were communicated to the Royal Society in March, 1772, it should not now be a matter for surprise that the Abbé Rozier in Paris, quoting in April, 1772, from his London correspondent, in the "Nouvelles Littéraires" in the monthly issue of his *Observations sur la Physique*[27], could report, not that "nitrous air" or a diminished form of it or "acid air" had been isolated, or that a chemical means of measuring the fitness of air for respiration had been devised, but only that Priestley had discovered that growing plants restored air vitiated by combustion and putrefaction (respiration not being mentioned). The report reads:

> "Monsieur Priestly, connu par une histoire de l'électricité, dont nous avons rendu compte, dans le Volume de Décembre 1771, page 36, a lu à la Société Royale de Londres, un Mémoire intéressant, dont nous nous empressons de faire connôitre le sujet; il est intitulé: *Recherches sur la nature de l'air & des parties qui le composent*[28]. Cet Ouvrage est fondé sur un grand nombre d'expériences curieuses, & M. Priestly y développe comment la nature supplée à cette prodigieuse quantité d'air consumé ou détruit par le feu & par la flamme, & il prouve par des expériences, que la végétation des plantes contribue à le remplacer & à lui faire reprendre ses qualités; que l'air vicié & infecté par les vapeurs qui s'exhalent des corps tendans à la corruption & dêja corrumpus, peut être renouvellé & réparé par l'air fixe qui s'échappe d'un corps en fermentation[29].
>
> "On a donné à un malade un lavement d'air fixe, produit par une combinaison d'acide vitriolique & de terre calcaire, & ce remede singulier l'a heureusement délivré d'une fievre maligne & putride, qui avoit résisté à tous les antiseptiques connus. Ce remede a été hasardé par un Chirurgien de la petite ville de Léeds".

It was, it is interesting to note, in "la petite ville de Léeds", as the Abbé's correspondent called it, in the years from 1767 to 1772 that Priestley made the experiments and discoveries that gained for him the Copley Medal, described by Sir John Pringle, President of the Royal Society, as "the palm and laurel of this Community". Here he had discovered that the common air of the atmosphere, "the breath of life", as Pringle called it, continually corrupted by

[27] April, 1772, pp. 280–281. Rozier subsequently published a full translation of Priestley's paper in April and May, 1773 (*Observations sur la Physique*, 1773, **1**, 292–325, 394–426).

[28] This title is incorrect. It could hardly be more incorrect.

[29] Although Priestley claimed that he had found that fixed air would "correct" air that had been "tainted with respiration and putrefaction", he would not "absolutely conclude" that this change was effected by the fixed air.

combustion, respiration and putrefaction, was as continually restored to its salutary state by the agency of living plants. He had shown how to prepare an artificial mineral water. He had obtained an inflammable air (our carbon monoxide) by heating lime-stone in a gun-barrel. He had shown that common air was diminished about one-fifth by putrefaction, by a mixture of moist iron filings and brimstone and by the calcination of metals. He had isolated and recognized two new "airs", namely "nitrous air" and "acid air". He had devised a quantitative chemical test for the purity of air. He had isolated a diminished form of "nitrous air". He had obtained the air that he was later to call "phlogisticated air" (nitrogen), but he was anticipated in this discovery by Daniel Rutherford; and he had found that it was "rather lighter than common air". He had observed that salt-petre yielded an air in which animals lived and in which "a candle not only burned, but the flame was increased"[30]; he was later to isolate it by other means and to call it "dephlogisticated air"; we now know it as oxygen.

The Copley Medal for 1772 was well earned—but not for soda-water.

* * *

The author is pleased to acknowledge his indebtedness to the Council of the Royal Society for permission to consult and quote from various manuscript documents preserved in the Society's Archives, including the Minutes of Council, the Society's Journal Book and the collection of Letters and Papers. His thanks also are due to the Librarian and his staff for their invaluable help.

[30] These two observations are recorded in the paper with which we are here concerned on pp. 184–185 and 245; the internal evidence from the MS. shows that Priestley announced these observations in March, 1772. The use of mercury to collect "acid air" was announced in November, 1772; Cavendish had previously (1766) stated that he had twice stored "fixed air" over mercury instead of water, to prevent loss by its solution in water, and that he had twice collected it over mercury. Priestley did not attempt to determine the diminution of air by respiration, because, he said (p. 264), he thought that "it had been done sufficiently by others, especially by Dr. Hales".

THE ORIGIN OF ALCHEMY

By Homer H. Dubs*

Alchemy has been, throughout its history, an attempt to transmute metals, especially to produce the precious metals from base ones, i.e. to "make gold". Along with such chemical attempts, there has also developed philosophical speculation about metals. If however "the hall-mark of alchemy is the combination of a spiritual and practical aspect in the making of precious materials",[1] all ancient workers in gold and silver were possibly alchemists, including the Babylonian artisans who examined Egyptian gold. For all such activity required sacrifices and prayer to certain gods! Here the term alchemy will however be restricted chiefly to its supreme goal—the "making" of gold out of baser substances. Roger Bacon called this procedure "practical alchemy" in contrast to theorizing about metals, etc., which he called "speculative alchemy".[2]

Alchemy is a romantic subject about which much legend has gathered. It is mysterious. It promises to make the initiate fabulously wealthy, to cure illness and produce immortality, thereby making the alchemist famous and honoured. But with such a romantic subject, modern historical critical methods are necessary—to ask who made each statement, when it was written, etc. To accept a 10th century A.D. statement about what is supposed to have happened in the 10th century B.C., as in some accounts of Chinese alchemy, is to court disaster. The best Chinese historical scholarship has been of very high quality. But there have also been abundant Chinese falsifications.

Modern chemistry has demonstrated amply that gold could not have been "made" by any procedure available to the ancients. Ancient Babylonia moreover possessed an unambiguous test for gold, now called cupellation. A mixture of metals, including gold and silver, is heated strongly for a long period in air, together with some lead, in a "cupel"—a porous vessel made of bone-ash. The lead and copper are oxidized and pass through the cupel, while the gold-silver remains in the cupel as a metallic button. The silver can then be removed by heating again in a cupel with some sulphur compounds, which convert the silver into its sulphide and allow it, too, to pass through the cupel, leaving the gold. Cupellation is a quite ancient procedure. It was

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[1] *Cf.* F. S. Taylor, *Ambix*, 1937, vol. I, p. 31.

[2] E. J. Holmyard, *Alchemy*, p. 117.

invented in north-eastern Asia Minor in the first half of the third millennium B.C.[3]. The "fining-pot" or "the refiner's fire" and the drossing of base metals are frequently mentioned in the Bible[4]. Babylonia anciently possessed a flourishing chemical industry, as shown by tablets found in the Nineveh library[5].

The most abundant source of gold in the ancient world was Egypt. So much gold was found there that Egypt had almost a monopoly of its production. Agatharchides (2nd century B.C.) mentions it[6]. From the 14th century B.C., there moreover comes a letter, found at Tell El-Amarna, in which Burra-buriaš II, King of Babylon (*ca.* 1375–1365 B.C.), writes to Amenophis IV of Egypt, "The twenty minas of gold were not complete, for when it was put in the furnace, it did not come forth five minas"[7]. Any culture that possessed such chemical knowledge could not have tolerated the "discovery" of alchemy—cupellation would quickly have demonstrated the falsity of any alchemical gold.

The above statement applies also to the so-called Egyptian "alchemy" of the first few centuries A.D. Two significant facts emerge from a study of their work: (1) these Egyptian workers themselves assert that they were taught by the "Mede, Ostanes",[8] (2) nowhere do they assert that they actually "make" gold. They prepared alloys that imitated the precious metals, either by treating the surface or by alloying[9]. Only in the later systematic Egyptian "alchemists", who collected the earlier writings, do we find any mention of

[3] Singer, Holmyard, and Hall, *A History of Technology*, vol. I, pp. 581–584.

[4] Job xxiii: 10; Ps. xii, 6; Prov. xvii, 3; xxvii, 21; Jer. vi, 29–30; Ezek. xxii, 20; Zech xiii, 9; Mal. iii, 3; Rev. i, 15; iii, 18.

[5] *Cf. Ambix*, 1938, vol. II, pp. 3–16.

[6] *Cf.* Singer, *et al., loc. cit.*

[7] J. A. Knudtzon, *Die El-Amarna Tafeln*; also S. A. B. Mercer, *Tell El-Amarna Tablets*, tablet 10, lines 19, 20; *cf.* also tablet 7, lines 71, 72.

[8] A. J. Hopkins, *Alchemy, Child of Greek Philosophy*, pp. 6, 67.

[9] *Ibid.*, pp. 61–66. On this supposed Egyptian alchemy, Prof. T. L. Davis observes, "The Alexandrian chemists, practising the imitative arts of the earlier Egyptians, were well aware that their products were not genuine materials. They no more thought of their yellow alloys and tinctured metals to be real gold than we think German silver to be real silver". From "The Problem of the Origins of Alchemy", *Scientific Monthly*, Dec., 1936, vol. 43, p. 555.

"making" gold[10]. Still more significantly, the word "alchemy" does not occur in any Egyptian or other writings of this period. A Jew who understood what is meant by a "fining-pot" could have demonstrated the falsity of any Egyptian alchemistic gold. Mary the Jewess, who is credited with the invention of the *kerotakis*[11], could hardly have been unaware of the chemical knowledge that is taken for granted in the Hebrew Bible. Egypt must then be excluded as a possible motherland for alchemy. Only when the Babylonian culture had been destroyed as a result of barbarian invasions, could alchemy have raised its head in Europe or in the Near East.

In ancient China the situation was quite different. China proper has never produced any large amounts of gold. Down to about the 5th century B.C., the Chinese language did not even have a word for gold. Confucius knew nothing about gold. When gold became known, it was called merely "the yellow metal (*huang-jin*)". Today, the second word in this phrase, *jin*, has indeed become the common word for gold, simply because there were separate words for all the other metals and there was no other ancient word for gold. This new use of the word *jin* was, however, quite different from the earlier use of that word. In Chinese inscriptions from the first half of the last millennium B.C., it is said that the king had given this noble some *jin* and that he had accordingly made the vessel on which the inscription occurs. In such cases, it is plain that then the word *jin* denoted any "metal", especially copper or bronze. Its later use for gold arose from increasing Chinese contacts with other parts of what is now China, or from visitors from other countries.

About the 4th century B.C., gold was found in a Chinese river in the present Jiangsi. A Chinese history, written in the 1st century A.D., the famous and quite reliable *History of the Former Han Dynasty*, mentions this gold placer as the only indigenous source of gold and adds that it had then already been practically exhausted. Today it is known that there is, or was, gold in all parts of China proper, but nowhere have there been, or are there, any large quantities of this metal. On the other hand, the head-waters of the great Siberian rivers anciently furnished gold abundantly. Tibetan rivers were only much later found to have gold. Between China and these Siberian rivers there were,

[10] Hopkins, *ibid.*, pp. 45–50, 69–77. The Leyden Papyrus deals with metal colouring (*op cit.*, p. 62) and Hopkins admits, "The early industry was not alchemy but close to it". (p. 70.) I have read through Berthelot's *Collection des Anciens Alchimistes Grecs*, especially Zosimus, with the original, and find there nothing that unmistakenly refers to the "making" of gold, but much that is concerned with the imitation of gold. The practising "alchemists" evidently knew quite enough about their subject to be aware of cupellation. Zosimus, however, who was an encyclopedist, may have thought that they made gold!

[11] Hopkins, *op. cit.*, p. 74.

however, the nomad people of the present Mongolia. They regularly raided the settled Chinese, so that there could be little commerce between the Chinese and these nomads, until they (the Hsiung-nu) became subject to the Chinese in the 1st century B.C. Archaic China knew almost nothing about gold.

In China, chemical knowledge developed quite slowly. Archaic Chinese armies used bronze weapons. The earliest mention of iron is dated only in 513 B.C.[12]. The first iron weapons date from the 4th or 3rd century B.C. The first long iron sword may date from only 227 B.C.[13] and iron spear-heads from about 301 B.C.[14]. Even in the first century B.C., the official test for gold was merely by its colour[15]. Ancient China was then a place that could serve well as a virgin soil for alchemy.

China was in occasional contact with Babylonia. The Chinese chariot differed from chariots of other countries in that the Han (1st two centuries B.C. and A.D.) Chinese chariot regularly possessed a fixed large umbrella that shielded its riders from the hot Chinese sun. European chariots were generally without such an umbrella. In the Louvre is a bas-relief of the Assyrian king Ašur-banipal (668–625 B.C.) in his war chariot, with an umbrella mounted on the chariot in the same manner that umbrellas were mounted in Han Chinese chariots[16]. Since there elapsed several centuries between Ašurbanipal and Han China, the Han chariot umbrella must have been imported from Babylonia, possibly in the time of Dzou Yen. Traders who transported Chinese silk anciently bridged the gap between these two cultures. Along with the chariot umbrella would naturally have come information about Babylonian metallurgy. Such an account, carried by a caravan leader, could easily have been interpreted to mean that the Babylonians made gold! Chinese weights were moreover standardized by taking, for four Han catties, the weight of a Babylonian standard now in the British Museum, which bears the statement that it was made by Nebuchadnezzar II (605–562 B.C.)[17]. Unfortunately, our detailed

[12] This mention is found in the *Dzo-juan*, and is dated Duke Jao, year xxix; *cf.* J. Legge, the *Chinese Classics*, vol. V, p. 732a.

[13] D. Bodde, *Statesman, Patriot, and General in Ancient China* (American Oriental Series, vol. XVII), p. 45.

[14] *Ibid.*, p. 48.

[15] Dubs, *History of the Former Han Dynasty* (abbreviated *HFHD*), II, p. 126.

[16] The bas-relief of Ašurbanipal is no. 62 of the Cat. Antiq. Assyrienne in the Louvre Museum. The Chinese representation is from a Han brick and attempts to represent a Chinese chariot of several centuries earlier.

[17] *Cf.* A. E. Berriman, "A Sumerian Weight-Standard in Chinese Metrology", *Revue d'Assyriologie et d'Archeólogie Orientale*, R.A. 52, 1958, no. 4. Dec., pp. 203–207, with which *cf.* H. H. Dubs, *The History of the Former Han Dynasty*, vol. I, p. 280.

information about Chinese history begins only with Han times. About 123 B.C., the Chinese emperor sent an envoy to Parthia[18] (then in control of Babylonia) and, about 110 B.C., the Parthians sent an embassy to China in return[19]. There must have been earlier contacts between these two cultures.

The earliest mention of alchemy in any authentic history is found in a Chinese imperial edict, dated in January or February, 144 B.C.:

> In the twelfth month the Emperor established the statute fixing public execution for coining cash or making counterfeit gold[20].

A learned Chinese glossator, Ying Shao, who lived about A.D. 140 to about 205, explains, in his note to this Chinese passage:

> Before this time, many people had made counterfeit gold. But counterfeit gold cannot in the end be made and vainly causes loss and expense and deceptive dazzling. When their funds are exhausted, such people rise up and become thieves and robbers. Hence the Emperor fixed this statute.

Meng K'ang, another glossator of A.D. 220–280, adds:

> Common people had at previous times made much false gold, hence the saying, "If gold could be made, the world could be measured". The loss and expense is very great, yet in the end gold is not produced. The common people moreover to a certain extent understand this fact, so that violators of this ordinance are few. Hence the Emperor fixed this statute.

This imperial edict, together with these later explanations thereof, establish that alchemy was already current in China in the 2nd century B.C. At that time alchemy was classed with counterfeiting as a penal offence. Its origin must be dated before that time.

We may discover this origin from a later incident. Liu Hsiang (lived 79–8 B.C.) was a relative of the Han emperors. Scholar, author, poet, astronomer, librarian of the imperial library, editor of important books, compiler (with others) of the great imperial bibliography, this man enriched many fields of scholarship. He was also one of the very few intelligent persons who at that time was not a Confucian and who still studied the Daoist (or "Taoist") philosophy, which at that time was almost untouched by intelligent persons. His father was Liu De, who, in his capacity as Superintendent of the Imperial House (which included all imperial relatives on the male side), had been sent

[18] *Shzh-ji* 123: 22, trans. in J. J. M. de Groot, *Die Westlande Chinas*, pp. 27, 28.

[19] H. H. Dubs, *A Roman City in Ancient China*, p. 28.

[20] *HFHD*, vol. I, p. 323.

in 122 B.C. to punish the rebellious King of Huai-nan. This King had sponsored the largest and still-extant non-Confucian work in Former Han times, the syncretic *Huai-nan-dz*. From his father, Liu Hsiang, then still a young man, had secured some books which the King of Huai-nan had treasured so greatly that he had kept them in his high hollow pillow. They were entitled, as stated in Liu Hsiang's memorial to the throne, "The Great Treasure (*Hung-bao*)" and "The Secret of the Park (*Yüanbi*)". The Chinese history, the *Han-shu*, probably basing itself upon Liu Hsiang's original memorial to the throne, states that these "books spoke of divine immortals and the art of getting spiritual beings to make gold, together with Dzou Yen's recipes for the repeated method and of prolonging life, which people of that age had not seen"[21]. (The "repeated method" was the Chinese designation for the alchemical procedure of repeatedly heating a mixture). The King of Huai-nan had kept these books in his pillow because thus he would not neglect them and they could remain secret.

The name of Dzou Yen is important, for this man was a Chinese philosopher who lived in the 4th and 3rd centuries B.C. and who deeply impressed important people of his own age, but who is hardly mentioned in modern accounts of Chinese philosophy[22]. He seems to have been the "discoverer" of alchemy. He was the sort of person who could deeply impress the persons with whom he talked. He, however, faded into insignificance as Confucianism became more and more dominant. A contemporary of the famous philosopher, Mencius, he was in his life time immensely more successful than even Mencius in securing the adherence of kings! He lived in a period when China had broken up into numerous independent states, who fought with each other. It was plain that one state would conquer the others and unify China, but which one would win was not yet apparent. Dzou Yen developed a theory of history that promised to predict which state would conquer, by the omens that come in advance. Consequently keen thinkers sought out this philosopher. When Dzou Yen came to the state of Liang, its King came out of his city to welcome him and treated him as an honoured guest. When he went to the state of Jao, the Prince of Jao gave Dzou Yen the centre of the road and walked to one side, personally brushing off Dzou Yen's mat before allowing him to be seated. When he went to the state of Yen, the King of Yen (whose capital was near the present Peking) went ahead of him as his advance guard, holding a brush to

[21] The *Han-shu*, ch. 36: folio pg. 6b. The statement probably come from Liu Hsiang's memorial about them to the throne.

[22] For Dzou Yen, *cf.* Fung Yu-lan, *A History of Chinese Philosophy*, trans. by D. Bodde, vol. I, pp. 159–169.

sweep away stones, etc., on the road, and asked his permission to become his disciple. This King built a palace for Dzou Yen at a retired and rocky place near the coast, to which the King went to receive Dzou Yen's instruction. Such a location was considered ideal for alchemical experiments. Dzou Yen seems to have settled there. The chapter now entitled "The Great Plan" in the Confucian *Book of History*[23], and the chapter "The Ordinances for the Months" now in the *Book of Rites*[24], come from the school of Dzou Yen. These two chapters were put into the authoritative Confucian "Classics" in Han times because they contain no alchemy. From what we know about Dzou Yen and his followers, he appears to have been a grandiose speculator, postulating relationships between such items as the five planets, the five high gods, the four (or five) seasons, the four (or five) quarters of the compass, the five colours, tastes, notes of the scale, viscera, etc. These became a feature of Han and medieval Confucianism. Dzou Yen's alchemical writings have perished, for this art had been made a crime and Chinese histories of the Han period[25], which were written by government officials, tell nothing that would instruct their readers how to commit crimes! Not until the two Han dynasties had perished do we find any good accounts of Chinese alchemical work. The *Shzh-ji*[26] tells merely that people from the state of Yen practised the method of becoming immortals by magical recipes and declared that, beginning about 300 B.C., kings of the states in this part of China sent people out into the present Gulf of Pechili to seek for some magical island mountains containing immortals[27].

From the Former Han period, i.e. the last two centuries B.C., there, however, comes a semi-alchemical passage, now found in the *Huai-nan-dz.* It contains the earliest extant Chinese mention of the alchemical metal, quicksilver. It

[23] The chapter entitled "the Great Plan" is in the *SHOO KING*, J. Legge, trans., "The Chinese Classics", vol. III; *Shoo King*, vol. II, pp. 321–344; better in B. Karlgren, trans., *The Book of Documents*, "Hung Fan", pp. 29–35.

[24] J. Legge, trans., The *Li Ki*, in the "Sacred Books of the East", vol. 27, pp. 249–310; S. Couvreur, trans., *Li Ki*, vol. I, pp. 538–572.

[25] There were two Han periods: the Former Han, 206 B.C. to A.D. 8, and the Later Han, A.D. 25 to 219, with, in between, the interregnal reign of a maternal relative of the Han clan.

[26] This is the first Chinese general history, written in the decades preceding 80 B.C., by the Grand Astrologer at the Chinese imperial court, Sz-ma Ts'ien. It has been translated (in part) by E. Chavannes, under the mistaken title, *Les Memoires Historiques*. It is highly reliable when dealing with the periods close to that in which it was written.

[27] *Cf.* H. H. Dubs, "The Beginnings of Alchemy", *Isis*, vol. 38, Nov., 1947, p. 65 f, for a fuller account of this movement.

describes how each of "the five metals (gold, lead, copper, silver, iron)" metamorphose naturally, in periods of five hundred years or a millennium, from a mineral into a quicksilver, into a metal, into a dragon, into a subterranean spring, into clouds, and finally into a sea[28]. Quicksilver is here what later alchemists call a "spirit", exhibiting its properties when associated with other chemicals. This passage may indeed have been taken from Dzou Yen's writings, which were all lost during Han times.

In 133 B.C., a professed "immortal" came to the court of the Han Emperor Wu, who was then only twenty-two years of age. This Emperor was an absolute autocrat, who disregarded laws, such as those about alchemy, since they were obligatory only on his subjects. This "immortal", Li Shao-jün, said that he had achieved long life by worshipping the Stove and eating no grain, so that he commanded supernatural beings and was able to drive away old age. He stated that he always appeared to be seventy years of age and had no wife, children, or relatives. To an old man at the imperial court, ninety years of age, this "immortal" said that he had practised archery with the old man's grandfather at a place which the old man recognized. At an imperial audience, Emperor Wu asked him about a vessel that the Emperor held in his hands. Li Shao-jün told him that eight centuries previous it had been placed in a certain tower by a famous duke—and it was found to possess an inscription with this duke's name! He told the Emperor, "You should sacrifice to the Stove and then you can bring supernatural beings to come. When they arrive, cinnabar sand will metamorphose into gold. When this gold has been made, it can be used to make utensils for eating and drinking and you can thereby increase the length of your life. Then immortals from the magical island mountains can be brought to come, whereupon, by making certain sacrifices, you will become an immortal". So Emperor Wu, too, attempted making alchemical gold. This "immortal" however after some time became ill and died. Yet the Emperor did not nevertheless disbelieve in alchemy. Various other practitioners likewise came to his court[29].

China in that period moreover gave alchemy a rigorous test. About 60 B.C., Liu Hsiang, the man previously mentioned, who was then only nineteen years of age, told his distant cousin, Emperor Süan, that he could make gold for the government. He relied upon the books secured by his father from the King of Huai-nan. Emperor Süan was no bigot. He placed Liu Hsiang in charge of a government workshop that made gold and silver articles. There Liu Hsiang could secure the assistance of the best alchemical experts in the country and

[28] For a translation of this passage, *cf.* Dubs, *ibid.*, pp. 70–73.

[29] *Cf.* Dubs, *op. cit.*, pp. 67–69.

have access to the government treasury. For several years Liu Hsiang worked without success. Finally, in B.C. 57 or 56, after having spent large sums of money, it became clear that he could not succeed. Liu Hsiang's aged father, the Marquis, accordingly reported to the throne his son's failure. By this time, very likely, a knowledge of cupellation had reached China, so that any alchemical gold could be shown to be merely an alloy. Liu Hsiang was accused of having violated the law of 144 B.C. against alchemy, tried, and sentenced to death. His father had died soon after making the report and Liu Hsiang's brother, who had newly succeeded to the marquisate, offered to return half of his territory to the government as a ransom for Liu Hsiang's crime. A formal court discussion was duly held concerning this case and it was concluded that this offer should be accepted. Liu Hsiang lived to become an important scientist and scholar. But he did not again attempt any alchemy[30].

Liu Hsiang's attempt should have been a decisive deterrent to alchemy. A highly intelligent and enthusiastic man who was an imperial relative and possessed the secret books on that subject, he had been placed in charge of a government bureau that worked in precious metals, had no lack of funds, and was allowed to work as he pleased for some years with whatever assistants he chose. A fairer trial for alchemy could hardly be imagined. Since he himself admitted failure, there should have been no doubt about it.

The explanation of alchemical failure common since that time soon, however, appeared. Huan T'an (lived *ca.* 40 B.C. to *ca.* A.D. 29) tells a story about a man who tried again and again in vain to make gold. His wife came from a family that possessed secret recipes. For some time she watched him vainly cooking his quicksilver mixture. Finally she asked him to let her try. She took something out of a bag and threw a very little into the retort on the stove. It was absorbed and in a little while she turned out the mixture. It had become silver! Her husband turned on her and asked why she had not previously told him. Her reply was that this secret was owned by her own clan and could not be divulged by others. Her husband however persecuted her for the secret so cruelly that she committed suicide rather than reveal the secret. Here appears for the first time what later alchemists called "the philosophers' stone"—the secret ingredient necessary to bring about alchemical success and the explanation of any alchemical failure. Thereafter, despite Liu Hsiang's failure, alchemical experimentation could proceed unhindered. So the philosopher's stone was a Chinese invention too![31]

[30] For a translation of the Chinese account of Liu Hsiang, *cf. ibid.*, pp. 74–78, with its notes.

[31] For a fuller account, *cf. loc. cit.*, p. 78.

After the collapse of the Later Han dynasty in the 3rd century A.D., China was for a time divided into three kingdoms. Not until the 7th century was China again unified for any long period. With the downfall of the Han dynasty, Confucianism, too, fell into disrepute. Daoism[32] became important, later Buddhism. Consequently alchemy became a respectable pursuit, so that there have come down Chinese works of that period dealing with this subject. Some of them have been translated or excerpted in English.

The most important of these writers was Go Hung (lived A.D. 254–334), who adopted the pseudonym "Bao-p'u-dz", a phrase meaning "the Master Who Maintains His Pristine Simplicity"[33]. A voluminous writer, dying at the age of eighty, he travelled widely, searching for rare books. He finally retired to a mountain in south China, far from the civil warfare. He was properly an encyclopedist, rather than an alchemist. His writings show that alchemy was being actively prosecuted in third and fourth century China[34]. He states that the best medicine to produce immortality is cinnabar. The next best are gold, silver, the supernatural mushroom, the five metals, mica, realgar, etc. The least good is resin from the pine and cypress. There are 120 species of mushrooms. Dry the best of them in the shade and eat them. You will then live as long as heaven and earth or from one to two thousand years. Or eat mica or jade, after dissolving them. By taking this medicine for one year, you will be cured of all desires. In three years, you will become young, and in five years you will be able to control spirits and ordinary gods and will meet immortals. Then you may attain immortality[35]. This later Chinese alchemy has been well recounted, so that it is not necessary for us to relate it.

The greatest medieval Chinese dynasty, the T'ang, was officially Daoist. Its ancestry is traced back, in the official Chinese history for that period, to the

[32] This Chinese word is commonly spelled "Taoism", but should be pronounced with an initial letter *d*.

[33] This name he gave to his most important work. It implies the Daoist doctrine that to be continuously "natural" is the ideal philosophic attitude.

[34] Various of his works have been translated or summarized in the *Proceedings of the American Academy of Arts and Sciences*, vol. 70, pp. 221–284; vol. 74, no. 10, pp. 297–325, and in *Monumenta Serica*, vol. 6, 9, 11. This later Chinese alchemy is comparatively well known, so need not be elaborated here; *cf.* E. J. Holmyard, *Alchemy*, pp. 31–35.

[35] For the above, *cf. Proceedings of the American Academy*, vol. 74, p. 311 f. There is a long bibliography on Chinese alchemy on p. 624 of the issue for Oct., 1940 of *Ciba Symposia*, pub. by the Ciba Pharmaceutical Products, inc., Lafayette Park, Summit, N.J., U.S.A.

Lao-dz, the legendary 6th century B.C. founder of Daoism[36]. Consequently this dynasty was not inhibited by Confucian condemnation of superstitions. The founder of the Sui dynasty, which preceded the T'ang by only thirty-odd years, drank alchemical longevity potions[37]. One of the T'ang emperors is believed to have died from a careless overdose of the elixir, administered by a eunuch. Since mercury was an inevitable ingredient in alchemical elixirs, this circumstance is not surprising. Later, about A.D. 1000, the nature of Chinese alchemy altered from the use of chemical medicines into the cultivation of mental discipline to produce equanimity under all circumstances[38]. Thereafter alchemy declined in China, until in the last three centuries alchemy practically disappeared there.

The derivation of the word "alchemy" in European languages has been doubtful, chiefly because the Chinese origin of this "art" has not been recognized. The *Oxford English Dictionary* derives this word from the Arabic *al*, which is the Arabic definite article (correct), and the word kīmīa, in which it finds the Greek word *κημία*, supposedly a Greek form of the native name of Egypt (from "Khem", "black earth"). But that an originally Greek word, used by Diocletian, should have had to travel to Arabic countries and add the Arabic definite article, only coming into European use afterwards—this strange circumstance is left unexplained. The ancient common knowledge of cupellation moreover turns Egyptian "alchemy" into an art of imitating precious metals. The Turkish author al-Safadī (696–7–764) suggested for "alchemy" the fanciful literary etymology that it comes from *kīm-yah*, meaning "the science from God (Yah)". Recently Dr. S. Mahdihassan of Karachi, Pakistan, has declared, merely on the basis of its pronunciation, that the Arabic *kīmīa* is derived from the modern Fukien Chinese dialectical pronunciation for the Chinese phrase now pronounced *jin-yi*[39].

[36] This man, whose designation "Lao-dz" can be correctly translated as "The Venerable Viscount", lived in the 4th and 3rd centuries B.C. His son was ennobled as a Viscount in 273 B.C., so that his aged father was naturally given this designation; *cf.* H. Dubs, "The Identification of the Lao-dz", *Jour. of the American Oriental Society*, vol. 61, Dec., 1941, pp. 213–221; vol. 62, pp. 300–304.

[37] *Sui-shu*, I: 15a.

[38] *Cf.* D. Waley, "Notes on Chinese Alchemy", *Bulletin of the School of Oriental Studies*, no. 6, pp. 1–24, 1102–03.

[39] This derivation was originally published in an article, "The Chinese Origin of Three Cognate Words, Chemistry, Elixir, and Genii" in the *Jour. of the University of Bombay*, Sept., 1951, vol. XX, part 2, p. 107. He pointed out that Arab merchants came to the famous Chinese port of Zaitun, near the present Amoy, China. He has since republished this derivation at various times: "Alchemy, in its proper setting, with Jinn, Sufi, and Suffa, as Loan-words from the Chinese", *Iqbal*, Lahore, Jan., 1959, vol. VII, no. 3; "Alchemy and its Connection with Astrology, Pharmacy, Magic and Metallurgy", in *Janus*, vol. XLVI, no. 3, 1957; "Chinese Origin of Alchemy" in *United Asia*, pp. 241 (date not specified).

This Chinese phrase, *jin-yi* 金液, was pronounced in T'ang times at the imperial capital as *kiəm-iŏk*[40]. This phrase means, literally, "the juice (or sperm) of gold". It was one of the common Chinese names for the elixir of immortality. Like other alchemical phrases, it disappeared from usage with the decay of Chinese alchemy. In medieval Chinese writings, there are abundant instances of its use. The *Lie-sien Juan*[41] tels a story that Master Ma Ming followed the ancient Master An Ch'i and received from him the recipe for the supernatural medicine *jin-yi*. Thereupon he compounded the elixir, *jin-yi*, upon Mt. Hua-yin. (Chinese alchemists believed that alchemical work is best done in retirement upon a sacred mountain and cannot be done in an imperial or royal court, where Liu Hsiang tried it.) But Ma Ming did not wish to ascend to heaven, so merely took a half dose and became an earthly immortal! The famous poet Shen Yo (A.D. 441–513) in one of his poems says,

> I wish to receive a tablet with the recipe for the *jin-yi*
> Which will tell me how to grow wings.

So popular did the concept of the *jin-yi* become, that the T'ang emperors used it as the name of the audience hall in their palace at the capital. Two months before his death, the second and greatest of the T'ang emperors, Li Shzh-min, on 9 May, A.D. 649, gave an imperial command to his Heir-apparent to go to the Jin-yi Gate Audience Hall and attend to the government business[42]. The term *jin-yi* was common in Daoist Chinese literature during T'ang times. With this name for the imperial audience hall, it could hardly have escaped the notice of travellers from Mohammedan countries, of whom there were many. The identity of Chinese with later Arab recipes, and the many identities between Arabic and Chinese alchemy, demonstrates that the Arab world secured its knowledge of alchemy from China. This identity is reinforced by the circumstance that the word *kimia* in Arabic does not denote primarily an abstraction, as in the English word "alchemy", but denotes a substance, the means by which the transmutation of metals is effected. This is the meaning of the Chinese word *jin-yi* and not that of the English word alchemy.

As early as the 6th century, Chinese travellers were passing through what was later to become Moslem territory and were expatiating upon Chinese

[40] B. Karlgren, *Grammata Serica*, nos. 652a and 800n. This work is the standard book on ancient Chinese pronunciation. It was republished in the *Bulletin of the Museum of Far Eastern Antiquities*, Stockholm, 1957.

[41] A book probably written by some alchemical adept in the period 200–420 A.D.; trans. and annotated by M. Karltenmark, under the title "Le Lie-sien tchouan", Pekin, 1953.

[42] *T'ang-shu* 3: 12a (Be-na ed.).

achievements, including items in the circle to which alchemy belonged[43]. In T'ang times (7th and 8th centuries), there were many such travellers, to as well as from China. In the *Arabian Nights Entertainments*, for example, its most marvellous stories, such as that about Aladdin, are located in China. Chinese graves of T'ang times contain many images of Moslem and other foreigners, which are today displayed in our museums. Djābir b. Haiyan (who is designated as the real founder of Mohammedan alchemy by J. Ruska) lived in the T'ang period. In those days, there seems to have been almost weekly travel from Mohammedan to Chinese centres. There were thus ample opportunities for Chinese ideas to reach Mohammedan centres, where chemistry was newly flourishing. So it is not surprising to find for the Arabic word "alchemy" a Chinese original.

The other outstanding alchemical term, *elixir*, also comes from an Arabic phrase, *el iksīr*. Here *el* is the Arabic definite article. The word *iksīr* is probably derived from the Chinese phrase now pronounced *yi-jzh* 液汁. In T'ang times it was pronounced *iäk-ts'iət*[44]. The final glottal stop in the first Chinese word plus the dental sibilant that begins the second Chinese word could easily produce the Arabic sound of *ks*, while the two vowels in the second Chinese word would produce an Arabic long vowel. The final Chinese *t* was a clusil consonant, as in the present Chinese Yangdz dialects, in which the tongue closes the mouth, after which the tongue is relaxed without any explosion. Such a consonant could not be produced by visiting Moslems, so that they substituted their letter *r*. This Chinese phrase, *yi-jzh*, denoted the substance of a fluid secretion, i.e. the active agent in the elixir. So, about the time that alchemy was beginning to decay in China, it was transferred to Arab countries and given new life there and later in Europe.

In China, alchemy was undoubtedly responsible for many chemical discoveries, especially the wonderful colours of medieval Chinese pottery. The famous calligrapher, Wang Hsi-jzh (lived A.D. 321–379), for a time associated with a Daoist, Hsü Mai. Together they would go out into the mountains, searching for peculiar stones, grinding them, and drinking the infusion. Wang Hsi-jzh is said to have declared that, if he kept up this practice, it would kill him[45].

While the promise of immortality could preserve such beliefs for many centuries, no intelligent people would retain it permanently. After the T'ang

[43] *Cf.* the passage quoted in Dubs, "Beginnings of Alchemy", *Isis*, vol. 38, p. 84, n. 135.

[44] B. Karlgren, *op. cit.*, nos. 800n, 686f. In Chinese there are no hyphens, so that this compound is written as two words.

[45] *Dzin-shu*, 80: 5b (Be-na ed.).

dynasty had collapsed, Confucianism, now revitalized and reformed, again became important, along with the Confucian belief in a supreme invariable principle governing the universe. In such an atmosphere, alchemy could not survive. For a time it became a purely mental discipline, removing disappointments by the refusal to desire things. Then it became a popular superstition and finally it died. During the last three centuries, there has been no intelligent alchemistic activity in China. So Chinese alchemy succumbed to Chinese philosophic monism, just as in Europe alchemy produced and then succumbed to science, which is another monistic intelligent activity. It is therefore not surprising that Europeans, coming to China in the last century, have reported nothing impressive about Chinese alchemy. That activity had been intellectually dead for so long that it was not even suspected to have been the source from which other alchemies sprang. In both civilizations, alchemy, however, produced many discoveries and advances in civilization.

ON SOME PRE-PUBLICATION COPIES OF LAVOISIER'S *TRAITÉ* (1789)

By Douglas McKie*

In 1954, when I was attempting to trace King Louis XVI's copy of Guettard and Monnet's *Atlas et description minéralogiques de la France* (Paris, 1780) among the scientific books from the former Royal Library in the Château de Versailles[1], my attention was drawn by Mlle Agnès Joly, conservateur à la Bibliothèque de Versailles, to the King's copy of Lavoisier's *Traité élémentaire de chimie* (Paris, 1789), now preserved in the Versailles Library. This proved to be a copy in one volume with only 558 pages of text instead of the usual two volumes with 653 pages of text and two unnumbered pages of errors and additions[2]; it was identical with another copy already known to me in the Bibliothèque Nationale in Paris and formerly belonging to Queen Marie-Antoinette. Both these copies are gilt-edged, bound in the old royal binding of full red morocco and gold-tooled with their respective coats-of-arms on both covers.

Since by established custom the Directeur of the Académie Royale des Sciences had in the course of his duties to attend on certain occasions at the Court of Versailles for audiences of the King, the Queen, Monsieur (the King's elder brother) and other members of the Royal family, for the purposes of presenting newly elected Academicians and of offering copies of the works of the Académie and of its members, it appeared that the volumes mentioned in the preceding paragraph were two of such royal copies. Lavoisier had been nominated Directeur of the Académie on its reorganization in 1785 and the ceremonial and the details of two audiences in that year, which in all probability resembled those of other years, have been described by Grimaux. It is interesting to quote his description, which is as follows:

> "Comme directeur, il avait encore à présenter au roi, à la reine, à la famille royale et aux ministres, les académiciens nouvellement élus, et à offrir les volumes publiés par les soins de l'Académie. Tout un cérémonial était réglé pur ces présentations; la veille, l'huissier de l'Académie se rendait à Versailles, porter des billets au premier gentilhomme de la chambre du roi, qui était alors le duc de Fronsac; à la première dame d'honneur de la reine, la princesse de Chimay, et au gouverneur du dauphin, le duc d'Harcourt. Au mois de janvier, le dimanche 16,

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[1] These books will shortly be discussed elsewhere.

[2] The preliminary pages, [i]–xlviii in the former and [i]–xliv with [i]–viij in the latter, are not counted in these totals.

> Lavoisier présenta l'abbé Tessier, Quatremère-Disjonval et Fourcroy, directeur du génie, reçus en 1784, et offrit le volume de l'Académie pour 1781 en même temps que l'*Histoire des comètes* du Père Pingré. Au mois de juillet, il présentait Charles, Broussonnet et Fourcroy le chimiste, récemment élus"[3].

Grimaux adds:

> "Reçus à onze heures et demie chez le roi, à une heure chez la reine les officiers de l'Académie eurent encore à voir les ministres, le contrôleur-général, le Dauphin, le comte et la comtesse d'Artois. Après les présentations, ils furent retenus à dîner chez le baron de Breteuil (le dîner était à trois heures). C'est le baron de Breteuil qui, ce même jour, présenta au roi l'illustre Lagrange"[4].

Following the finding of Louis XVI's copy of the *Traité*, a search in other libraries in Paris revealed the existence of two further copies, each in one volume with only 558 pages of text, similarly bound and similarly tooled and ornamented. One of these in the Bibliothèque Sainte-Geneviève carries the arms of the Comte de Provence, the other in the Bibliothèque de l'Arsenal those of the Comte d'Artois. The covers of these four royal copies are shown in Plates I to IV. Provence was the elder brother of Louis XVI and was, therefore, according to custom, generally referred to as Monsieur without any further title; he was born in 1755 and reigned as Louis XVIII of France from 1814 until his death in 1824. Artois was Louis XVI's younger brother; he was born in 1757, succeeded Louis XVIII in 1824 as Charles X and died in 1836.

At the same time I traced a copy of the *Traité* with only 558 pages of text in the Bibliothèque Mazarine, Paris; this is bound in leather and bears no coat-of-arms. A second copy bound in leather without a coat-of-arms and with the same number of pages had long been known to me in the Bibliothèque Nationale; and a third such copy is in the possession of Mr. Denis Duveen. These three copies will be referred to later.

In a note[5] published in 1950 Duveen described the copy in the Bibliothèque Nationale bearing the arms of Marie-Antoinette and the other copy, then temporarily mislaid there, together with the copy in his possession, the only three such copies known to him, as copies of the first edition of the *Traité*, but in his later bibliographical study with Klickstein[6] they were described as a first

[3] Édouard Grimaux, *Lavoisier 1743–1794 d'aprés sa correspondance, ses manuscrits, ses papiers de famille et d'autres documents inédits*, 1st edn., Paris, 1888, p. 144. The first Fourcroy mentioned by Grimaux is Fourcroy de Ramecourt (1715–1791), maréchal des camps et directeur des fortifications.

[4] *Ibid.*, foot-note 1.

[5] *Isis*, 1950, **41**, 168.

[6] D. I. Duveen and H. S. Klickstein, *A bibliography of the works of Antoine Laurent Lavoisier 1743–1794*, London, 1954, pp. 160–173.

issue of the first edition, the second issue being taken to be what had formerly been known as the first edition, namely, the edition published in Paris in 1789 in two volumes with a total of 653 pages of text continuously paginated and for a time (1950–54) described by Duveen as the second edition. It does not, however, seem appropriate to describe even as a "first issue" of the first edition the three copies mentioned by Duveen, or the seven copies now recorded here, because they do not appear to have been published but to have been author's pre-publication copies. Their rarity, the bindings of four of them, and the omission of almost a hundred pages of tables, index, reports and corrections are all in agreement with this view. The chief difference between these seven copies and what has usually been referred to, and, it is here considered, correctly referred to, as the first edition is that the former do not contain certain concluding sections that appear in the latter, namely, the "Tables à l'Usage des Chimistes" (pp. 561–591), the "Table des Matières" (pp. 592–619), the reports from the Académie Royale des Sciences, the Société Royale de Médecine and the Société Royale d'Agriculture (pp. 620–653), dated respectively 4 February, 6 February and 5 February, 1789[7], and the unpaginated two pages [654, 655] of "Fautes à corriger, & Additions", all of which appear on pp. [559][8]–[655] of the latter; further, since the latter was published in two volumes, it has, where the former had one title-page, separate title-pages fo r

[7] It is interesting to note that in the "Nouvelle édition", the second edition, published later in 1789, the word "Royale" had been deleted from the headings of the printed reports both of the Académie and of the Société d'Agriculture, but not from that of the Société Royale de Médecine.

[8] P. [559] is a half-title, "Tables à l'Usage des Chimistes". Numbers given here in square brackets indicate pages that have not been numbered. The half-title, p.[559], is interesting. In the absence of the 'Tables', it was, of course, omitted from the pre-publication copies. Dr. W. A. Smeaton informs me, however, that, when he recently examined the unornamented copy in the Bibliothèque Nationale, he noticed that the reversed imprint of p.[559] could be clearly seen on p. 558, indicating that it was originally present and that the heavy type (capitals) used for the half-title was not yet dry when the sheet was folded; and I have verified that this is shown also by the copy in the Bibliothèque Mazarine. I have not at present had an opportunity of examining the other pre-publication copies. On my copy of the first edition, the reversed imprint is not present, and therefore the heavy type was dry when the sheet was folded. It is clear, however, that p.[559] was already printed when the pre-publication copies were made up; as it was the last page, Mm8*a*, of the last signature, Mm, of the gatherings included in these copies, it could easily have been and was, it seems, detached before these copies were bound. Mm8*b* is blank except for the catchword, 'Tables', for signature Nn, the first of the gatherings, Nn-Ss, added to the book shortly afterwards for publication. These details confirm the suggestion made in the text above that the gatherings for the pre-publication copies were assembled in haste and that the 'Tables' were not then ready for inclusion.

"Tome Premier" and "Tome Seconde", and the preliminary pages of the former, pp. [i]–xlviii, are divided in the latter so that pp. [i]–xliv appear in the first volume and the remainder are transferred to form pp. v–viij of the second volume. It seems probable that these seven copies, all lacking the hundred extra pages of tables, index and reports, and corrections and additions, were bound, for some reason that is not now known, before the extra pages of tables and index were ready and, of course, before the three reports of 4, 5 and 6 February could be printed and included.

There is, however, one simple explanation that may be considered. The special bindings of four of them, gold-tooled and with royal coats-of-arms, would take some time, and these four copies would presumably have to be passed to the appointed binders for binding and also for the stamping of the coats-of-arms; and Lavoisier would wish to have them ready for his approaching audiences at Versailles on 15 February, when, as a member of the Académie, he would according to custom present copies of his most recent publications. These copies have now been traced, namely, those presented to the King, the Queen, the Comte de Provence and the Comte d'Artois. The other three copies with only 558 pages may well be extra copies bound at that time for Lavoisier's own interest or use or for some other purpose.

The *Gazette de France* for Friday, 27 February, 1789[9], announced Lavoisier's visit to Versailles on 15 February and the presentation of the copies of his *Traité*:

> "Le 15 de ce mois, . . . L'Académie Royale des Sciences a eu l'honneur de présenter au Roi, à la Reine & à la Famille Royale le volume de ses *Mémoires* pour l'année 1786. En même-tems, le sieur Dionis du Séjour présenta le second volume de son *Traité analytique des mouvemens apparens des corps célestes;* & le sieur Lavoisier, un *Traité élémentaire de Chymie*, avec planches & descriptions de tous les appareils relatifs aux découvertes modernes".

A note added: "Cet ouvrage sera mis en vente, dans le courant de Mars chez' Cuchet, Libraire, rue & hôtel Serpente".

What of the three pre-publication copies without coats-of-arms? It would be tempting to suppose that these are the three copies submitted for report and approval to the Académie Royale des Sciences, the Société Royale de Médecine and the Société Royale d'Agriculture. This supposition must, however, be dismissed, because two of these reports, those by the Académie and by the Société Royale de Médecine, refer to the "Tables" that, as stated above, were not included in any of the pre-publication copies. The report from the Société Royale d'Agriculture does not refer to the "Tables", but there is no reason to suppose that the *rapporteurs* of this society received a copy different from those

[9] No. 17, p. 85. It will be observed that the *Gazette* used the spelling *Chymie* and that the bindery did likewise on the spines of these presentation copies.

submitted to their colleagues in the Académie and in the Société Royale de Médecine. However, examination of these reports brought to light an interesting detail. The reports, as already indicated, were reproduced in the first edition of the *Traité*. The report of the Académie, drawn up by d'Arcet and Berthollet, is dated 4 February 1789. The *rapporteurs* state:

> "Ces nouveaux élémens sont terminés par quatre tables; la première donne le nombre des pouces cubiques correspondans à un poids déterminé d'eau; la seconde est destinée à convertir les fractions vulgaires en fractions décimales, & réciproquement; la troisième présente le poids des différens gaz, & la quatrième, la pesanteur spécifique des différentes substances"[10].

The report of the Société Royale de Médecine, drawn up by de Horne and de Fourcroy, is dated 6 February 1789. The *rapporteurs* refer to the "Tables" as follows:

> "L'ouvrage est terminé par des tables où sont exposées la pesanteur du pied cube des différens gaz, la pesanteur spécifique d'un grand nombre de corps naturels, les méthodes pour convertir les fractions vulgaires en fractions décimales & réciproquement, des moyens de correction pour la pesanteur des gaz relativement à la hauteur du mercure dans le baromètre & dans le thermomètre. Ces tables deviennent aujourd'hui aussi nécessaires aux Chimistes pour obtenir des résultats exacts dans leurs expériences, que le sont les tables de logarithmes aux Géomètres & aux Astronomes, pour l'exactitude & la rapidité de leurs calculs"[11].

Reference to the *Traité* shows, however, that it contained eight tables numbered and entitled as follows:

I. *Table pour conventir les onces, gros & grains en fractions décimales de livre, poids de marc.*
II. *Table pour convertir les fractions décimales de livre en fractions vulgaires.*
III. *Table du nombre de Pouces cubes correspondans à un poids déterminé d'eau.*
IV. *Table pour convertir les lignes & fractions de lignes en fractions décimales de pouce.*
V. *Table pour convertir les hauteurs d'eau observées dans les cloches ou jarres, en hauteurs correspondantes de mercure exprimées en fractions décimales de pouce.*
VI. *Table des quantités de puces cubiques françois correspondans à une once, mesure de M. Priestley.*
VII. *Table des pesanteurs des différens gaz à* 28 *pouces de pression & à* 10 *degrées du thermomètre.*

[10] *Traité*, 1st edn., Paris, 1789, p. 627.

[11] *Ibid.*, p. 649.

VIII. *Table des Pesanteurs spécifiques des substances minérales, extraite de l'ouvrage de M. Brisson. Table des Pesanteurs spécifiques des Fluides. Table des Pesanteurs spécifiques de quelques substances végétales & animales*[12].

D'Arcet and Berthollet, although stating with a misleading air of accuracy that the *Traité* ended with four tables, which they described one by one in detail, differed from de Horne and de Fourcroy, who did not report that there were precisely four tables but referred to four, three of those mentioned by d'Arcet and Berthollet and one other not so mentioned. It would be extravagant to conclude that they had different copies in front of them; and, unless it be supposed that the *rapporteurs* of the Académie had momentarily departed from their customarily high standard of accuracy, it is difficult to know what conclusion to draw. But it is clear that the copies submitted for report contained the tables and that they were not copies with only 558 pages of text, bound without the tables, before the completion of the printing, for the purpose of expediting the reports. But where are these three copies? If they are extant, they should be found to lack the pages (pp. 620–653) that reproduce the reports.

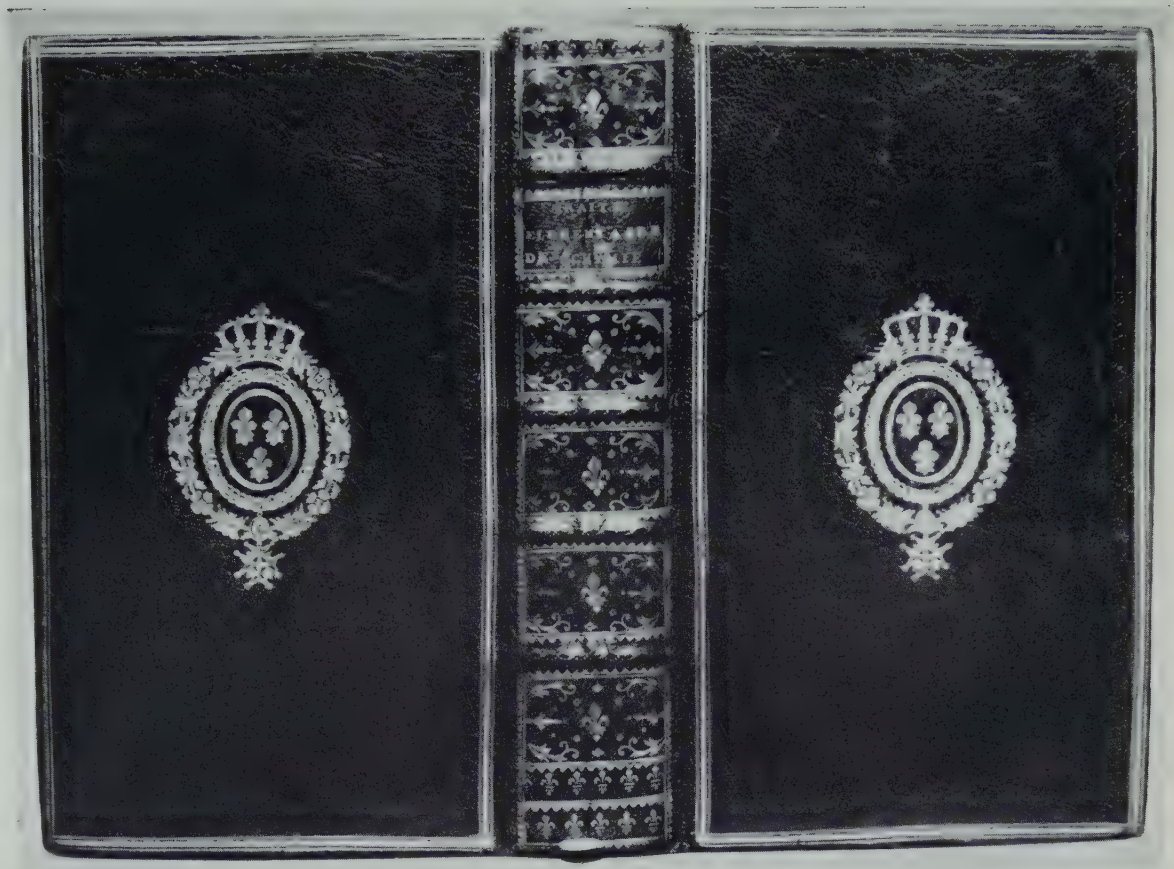
The legal importance of one of these *rapports*, namely, that of the Académie des Sciences, needs brief reference here. Works published either by the Académie as a corporate body or by any of its members individually did not have to be submitted to the censors. This exception to the general procedure has a long history. Article XXX of the *Règlement* for the Académie approved by Louis XIV in 1699 prohibited the publication of a book indicating on its title-page that its author was a member of the Académie unless it had been examined and approved by the Académie[13]. This relieved the censors of some scientific reading and they could thereafter act on the recommendations of the Académie. Following this, by an edict of 1704, the King granted a *privilège* for ten years permitting the Académie to print such books and to appoint an official printer for this purpose[14]. The censors were thus further relieved of their responsibility for the books of a not inconsiderable class of scientific writers. From time to time the *privilège* was renewed with slight textual changes. In 1750, when Louis XV renewed it for twenty years[15], it was ordered that *les manuscrits ou imprimés qui auront servi de copie à l'impression desdits Ouvrages* must be

[12] *Ibid.*, pp. 561–591. The work by Mathurin-Jacques Brisson (1723–1806), on which Table VIII is based, is *Pesanteur spécifique des corps* (Paris, 1787).

[13] See Fontenelle, *Histoire du renouvellement de l'Académie Royale des Sciences*, Paris, 1708, pp. 51–52.

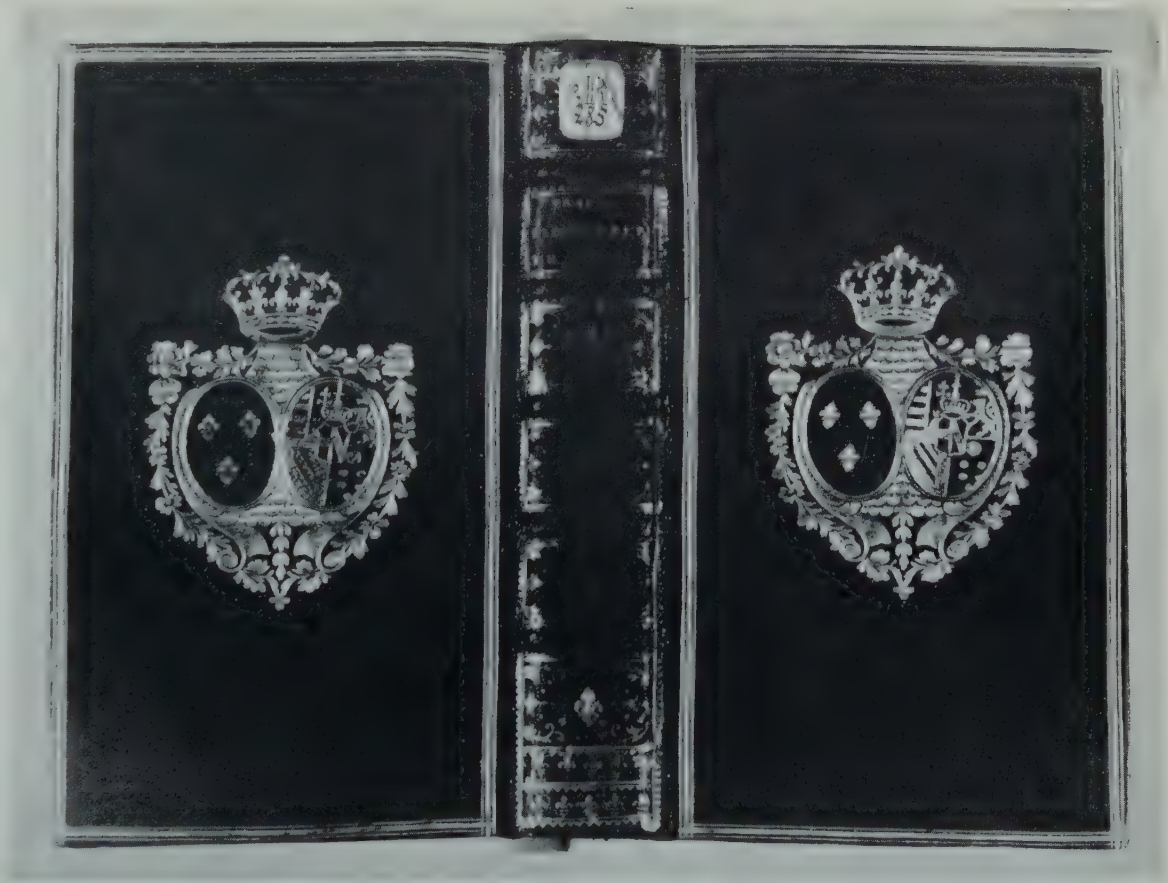
[14] The *privilège* of 1704 is reproduced at the end of Fontenelle's book referred to in the preceding foot-note.

[15] The *privilège* of 1750 is reproduced at the end of the third volume of Baumé's *Chymie expérimentale et raisonnée* (Paris, 1773).



King Louis XVI's copy of Lavoisier's *Traité* (1789). *By courtesy of the Bibliothèque de Versailles.*

PLATE I



Queen Marie-Antoinette's copy of Lavoisier's *Traité* (1789). *By courtesy of the Bibliothèque Nationale, Paris.*

PLATE II

The Comte d'Artois's copy of Lavoisier's *Traité* (1789). *By courtesy of the Bibliothèque de l'Arsenal.*

PLATE III

The Comte de Provence's copy of Lavoisier's *Traité* (1789). *By courtesy of the Bibliothèque Sainte-Geneviève.*

PLATE IV

deposited in the office of the Chancellor before such books were put on sale. The use of the word *imprimés* in this context would seem to indicate that a member of the Académie was allowed to submit for report a printed copy of his book and not necessarily a manuscript. It might, of course, be claimed that the word was intended to apply only to the printing of revised and later editions of works previously approved and published, for which printed copies with corrections and additions would be available and could be submitted. But this interpretation would force us either to suspect a lack of precision, rare but not entirely unknown, in the expert drafting of a legal document, revised in its exact phrasing from time to time with changing circumstances and of high importance because it authorized a strictly limited exception, or to assume an altogether unimaginable inflexibility in the French language in the composition of a simple clause intended to prescribe *manuscrits* for a first printing and corrected *imprimés* for revised and later editions. Neither of these insubstantial hypotheses is very attractive. It would seem more reasonable to conclude that Lavoisier, a lawyer by training and long experienced as an administrator in the drafting and interpretation of legal documents, was committing no illegality when he had some pre-publication copies of his *Traité* printed to submit for the three *rapports* that he sought. It can scarcely be supposed that he submitted three separate manuscripts. Certainly, when he presented the royal copies, his position was clear because he had then already received the approval of the Académie. It is also worth pointing out that there was nothing exceptional in his including in the published *Traité* the text of three *rapports*; in 1777 Macquer, then *doyen* of French chemists, had published extracts from three such *rapports* in the second edition of his *Dictionnaire de chimie*[16]. Neither the *règlement* nor the *privilège*, it may be added, ordered the publication of the *rapports*.

The first edition of the *Traité* was on sale in March; it was published in two volumes[17] in an edition of 2,000 copies by Cuchet, rue et hôtel Serpente[18].

[16] The first edition of 1766 was anonymous and was, therefore, not submitted for the approval of the Académie. The second edition appeared first in 1777 in 3 vols. octavo; three further impressions of this edition followed in 1778, two in 4 vols. octavo and one in 2 vols. quarto.

[17] It has been suggested that the book was bound in two volumes because it might have been unwieldy in a single volume. There is one very interesting copy bound in one volume; it formerly belonged to Alexandre Brongniart (1770–1847), mineralogist, and afterwards to his famous son-in-law, the chemist Jean-Baptiste Dumas (1800–1884); it is now in the Bibliothèque de la Faculté de Pharmacie, Paris. There is another copy bound in one volume in the Bibliothèque de l'Université de Paris. The fifth edition of Baumé's *Éléments de pharmacie* (Paris, 1784) is larger by over 200 pages and does not seem unwieldy.

[18] Maurice Daumas, *Lavoisier théoricien et expérimentateur*, Paris, 1955, p. 109.

The price was 10 livres in paper covers and 12 livres bound. A copy in the original reddish-brown paper covers is preserved in the Bibliothèque Centrale du Muséum National d'Histoire Naturelle, Paris; and I have seen and examined another such copy in private possession in France. The work was reviewed a month after its publication in the issue of Rozier's journal for April[19]. The reviewer, de la Métherie, in his opening paragraph wrote:

> "Les talens de l'illustre Auteur de ce Traité sont connus. Aussi l'Ouvrage a-t-il les approbations les plus flatteuses & les plus honorables des trois Compagnies savantes de cette Capitale, dont il est Membre. Celle sur-tour de la Société de Médecine a vingt pages d'un caractère très-fin".

The *rapports* had been formally completed and signed in the early days of February and were therefore printed to be included in the book when put on sale in March[20].

At Versailles Mlle Joly further drew my attention to certain marginal pencillings in the copy that had belonged to Louis XVI. These occur on p. 3 lines 2–3; p. 4, line 10 from foot; p. 7, lines 10–12 from foot; p. 8, line 4; p. 11, lines 9–11 from foot; p. 12, lines 9, 12, 14, with a mark opposite each of these three lines; p. 18, last three lines; p. 20, lines 16–18; p. 21, lines 10, 14–16, 21–24; p. 22, line 6; p. 26, lines 4, 8–12, 3 from foot; p. 27, lines 1–3, 6–9; p. 28, lines 1, 9, 15; p. 29, lines 2–4, 9–10; p. 30, lines 5–8 from foot, line 2 from foot; p. 31, lines 1–3 and lines 10–11 from foot; p. 32, line 3 from foot; p. 39, lines 9–10 and 3–4 from foot; p. 40, lines 11–12 from foot; p. 48, line 15; p. 49, line 17; p. 50, lines 10, 11, 15; p. 51, lines 9–11 from foot; p. 54, lines 2–3; p. 71, lines 11–12; p. 91, lines 7–10 and 2 from foot; p. 92, line 8; p. 95, lines 5–6; p. 98, lines 8–9, 18–19; p. 104, line 12; p. 105, lines 2–3, 12–13, 17; p. 106, lines 12–13 and 3–4 from foot; p. 132, last two lines; and p. 166, lines 6–7.

It would be impossible to say whether these pencillings, which might be contemporary, are in the hand of Louis XVI or of his time, especially since, as Mlle Joly informs me, there appears to have been general access during the 19th century to books from the Royal Library, but they are recorded here as a matter of interest. If, however, the text of the letter reproduced below is authentic[21], it would seem that Louis XVI had some taste for chemistry. His interest in mechanical crafts, particularly the craft of the locksmith, is well

[19] *Observations sur la Physique*, 1789, **34**, 304.

[20] It is known that two of them had been rapidly compiled. Lavoisier asked for the approbation of the Académie on 17 January (Daumas, *op cit.*, p. 109) and for that of the Société Royale de Médecine on 30 January (W. A. Smeaton, *The Library*, 1956, **11**, 132).

[21] The original is not available.

known, and it is commonly claimed that chemists are much interested in the mechanical arts, although the converse is not so often or so confidently asserted. The letter is said to have been written by the King to Lavoisier on 15 March, 1789. It reads as follows:

> "A M. de Lavoisier
>
> 15 Mars, 1789
>
> Votre dernière expérience, monsieur, fixe encore toute mon admiration: cette découverte prouve que vous avez agrandi la sphère des connoissances utiles. Vos expériences, sur le gaz inflammable, prouvent combien vous vous occupez de cette science admirable, qui, tous les jours, fait de nouveaux progrès.
>
> La reine, et quelques personnes que je désire rendre témoins de votre découverte, se réuniront, dans mon cabinet, demain à sept heures du soir. Vous me ferez plaisir de m'apporter le traité des gaz inflammables.
>
> Vous connoissez, monsieur, toute mon estime pour vous.
>
> Louis"[22].

The editor's observations on this letter are as follows:

> Les expériences que le roi engage l'illustre Lavoisier à répéter devant lui, et devant sa famille, sont la base du système de la nouvelle chimie française; mais, quoiqu'elles aient reçu l'approbation du monarque, et, depuis, l'assentiment de presque tout le monde chimique, il manque encore, à ce système, la sanction du célèbre physicien*, qui jeta le premier fondement, sur lequel on a élevé cet édifice aérien.
>
> Mais, en abandonnant le sort de ces gaz à l'impartialité des savans, qui pourroit s'empêcher de déplorer celui de l'infortuné Lavoisier, et d'exécrer ses horribles assassins?
>
> Dans cette lettre, le roi l'invite à venir répéter ses curieuses expériences, en présence de la reine, et des personnes de sa cour: quatre ans après, il supplia ses bourreaux de le laisser vivre encore quinze jours, pour qu'il pût déterminer le résultat d'une suite d'expériences importantes, qu'il avoit commencées depuis long-temps: mais ces hommes

[22] Helen Maria Williams, *Correspondance politique et confidentielle, inédite de Louis XVI . . .*, Paris, An XI–1803, 2 vols. The letter reproduced above appears in vol. i, p. 128. An English translation appeared as *The political and confidential correspondence of Lewis the Sixteenth . . .*, London, 1803, 3 vols. The Catalogue of the British Museum classifies these letters as 'spurious'.

Louis XVI's use of the *particule* in Lavoisier's name is, of course, correct. Lavoisier's father, who died in 1775, had acquired one of those many royal appointments in eighteenth-century France that at his death would confer the privileges of hereditary nobility on his son (Grimaux, *op. cit.*, pp. 40–41). Lavoisier himself does not appear to have adopted the style of de Lavoisier either then or later, although he was occasionally so referred to by others.

* Priestley. [This foot-note occurs in the source quoted.]

féroces furent sourds à ses prières. Ils ne connoissoient d'autre moyen de gouverner, que les confiscations; ils ne faisoient d'expériences que sur l'échafaud[23].

Helen Maria Williams (born, London, 1762—died, Paris, 1827), the editor of this correspondence, was an English writer, mostly resident in Paris from 1788. She was an enthusiastic supporter of the principles of the Revolution and she was a friend of the Girondists and of Mme Roland; she was imprisoned in the Luxembourg by Robespierre from October 1793; and as a result of the events of Thermidor she had a narrow escape from the fate of many of her friends. Her writings were much criticized either as factually erroneous or as unscrupulous fabrications, and the book here referred to was attacked as libelling the memory of Louis XVI, although it will be observed that the letter quoted above cannot be criticized on that account and that the annotation to the letter severely condemns the régime of Robespierre.

The text of the letter has an air of authenticity. On 15 February Lavoisier had presented to the King a copy of his *Traité*; on 15 March the King apparently commanded Lavoisier to Versailles to demonstrate his latest experiment on "inflammable air" and to bring his "traité des gaz inflammables". This phrase could have referred loosely to the *Traité* and the experiments might have been those proving that water was a compound of oxygen and "inflammable air", an astonishing discovery in its time and then much discussed in *milieux* other than the strictly scientific. The statement in the annotation that Lavoisier appealed for a stay of execution to enable him to complete some important experiments is, however, not supported by any known evidence. No claim is made here that this letter is genuine.

Acknowledgments

My thanks are due to M. Pierre Breillat, Conservateur de la Bibliothèque de Versailles, for his kindness in granting me access to that library, and to Mlle Agnès Joly for her interest in these matters, her invaluable help and her untiring patience in dealing with my numerous queries. I am indebted also to my friend, M. le Professeur Jacques Boussard, formerly of the Bibliothèque de l'Arsenal and now of the Université de Poitiers, and to Mme W. Wintzweiller of the Bibliothèque Sainte-Geneviève. Permission to reproduce the illustrations is acknowledged on the captions.

[23] *Ibid.*, vol. i, 129–130.

THOMAS BEDDOES AT OXFORD

By F. W. Gibbs and W. A. Smeaton

References to the time when Thomas Beddoes (1760–1808) began actively working and teaching chemistry in the University of Oxford are so conflicting that we have compared notes to see if a consistent account of the order of events in 1786–7 can be given. The records of the two Colleges with which he was associated (St. John's and Pembroke) and the University archives reveal nothing, and this suggests that he had an independent status throughout his stay. He certainly had no remuneration from the University, and he was entirely dependent on fees received from the students who attended his lectures[1]. Whether he is called lecturer, reader, or professor[2] is thus immaterial, for none of these terms appears to have had any precise significance in relation to Beddoes.

J. E. Stock, his biographer, stated that Beddoes returned from Edinburgh to Oxford to receive his M.D. on 13 December, 1786, spent the following spring at Edinburgh, the summer in the Highlands and the autumn on the Continent, visiting Dijon and Paris. Stock goes on to say that Beddoes then offered himself as a candidate for the "Chemical Lectureship" at Oxford, which had become vacant on account of the resignation of Dr. William Austin, shortly after his return from France (i.e. in the autumn of 1787)[3]. He thus implied that Beddoes began to lecture at Oxford at the end of 1787 or in 1788, and the latter date has been accepted by Gunther[4] and by Wheeler and Partington[5].

It is true that Beddoes received his M.D. in December, 1786[6], but Austin had already departed on becoming physician to St. Bartholomew's Hospital, London, in August, 1786[7]. There is considerable evidence that Beddoes was active at Oxford early in 1787, and it is important to note that many of Stock's

[1] J. E. Stock, *Memoirs of the life of Thomas Beddoes, M.D.*, London, 1811, 21.

[2] Though there was no professorship in Beddoes's time, he actively agitated for the creation of one. The first Chair in chemistry at Oxford was founded by the will of George Aldrich (proved 1798) not very long after Beddoes left Oxford, but it was not occupied until 1803, when John Kidd was appointed. We see no reason to assume (*see* e.g. Wheeler and Partington, ref. 5 below, p. 36, note 42) that the post of professor or reader was left vacant for some time after Austin's resignation because of lack of funds.

[3] Stock, *op. cit.*, 15–18.

[4] R. T. Gunther, *Early Science in Oxford*, Oxford, 1923, i, 67; 1937, xi, 277.

[5] T. S. Wheeler and J. R. Partington, *The life and work of William Higgins*, Oxford and London, 1960, 4; *ibid.*, 35–6, notes 39, 40.

[6] J. Foster, *Alumni Oxoniensis*, London, 1887, i, 86.

[7] Wheeler and Partington, *op. cit.*, 33–4, note 25.

dates are unreliable. He himself wrote in his preface: "Notwithstanding the friendly communications of many of the Doctor's friends, it was often extremely difficult to fix on a date, or to trace an incident in its exact order and connexion". It is therefore necessary to find independent ways of checking Stock's dates.

As regards the first—the spring and summer of 1787 spent in Scotland—only two pieces of evidence are known. Writing on 3 May, 1803, to Dr. Currie, of Liverpool, Beddoes described a medical incident which occurred on that excursion[8], and began the account by saying: "About seventeen years ago I traversed a part of the Highlands on foot". Now one does not say "about seventeen years ago" if there is any doubt as to the number of years; in that event some such phrase as "fifteen to twenty years ago" would suffice. We therefore take this to mean at some time around May, 1786. If this is accepted, Stock's order becomes wrong, and the most likely interpretation seems to be that Beddoes did not return to Scotland in 1787. All the known events of Beddoes's early days in Oxford then fit into place.

This view is consistent with what is known of Beddoes's relations with Edmund Goodwyn at Edinburgh, for he had been greatly impressed with Goodwyn's experimental study of respiration, which had resulted in a Latin treatise published there in 1786. This had attracted some attention and it was decided to print an English translation. Beddoes later said that they had corresponded about this when he was at Oxford. As a result, Goodwyn had sent him the corrected manuscript to look at, but owing to Beddoes's absence at the time it arrived, it was very nearly lost. This manuscript had been traced, returned to Goodwyn and got ready for printing by May, 1788, but Goodwyn himself was then called away and was unable to see it through the press[9]. The probability seems to be that Beddoes was on the Continent at the time the manuscript arrived (during the summer vacation, 1787), and since Goodwyn had been writing to him *at Oxford* before that, it again appears most unlikely that he spent the spring and summer of that year in Scotland.

Confirmation that Beddoes was at Oxford in March, 1787, is found in the notes of experiments on the production of artificial cold, carried out by Richard Walker, apothecary to the Radcliffe Infirmary. Walker's notes have been published by Gunther[10].

[8] Brit. Mus., *Add. MS.* 35262, f. 24.

[9] T. Beddoes, *Chemical experiments and opinions. Extracted from a work published in the last century*, Oxford, 1790, i–ii; *idem, A letter to Erasmus Darwin, M.D., on a new method of treating pulmonary consumption*, Bristol, n.d., 28–9. See also author's advertisement and introduction to E. Goodwyn, *The connexion of life with respiration*, London, 1788.

[10] Gunther, *op. cit.*, 1923, i, 204.

"1786, 28 April. 47° and 22° of Cold produced.
1787, 21 March. Dr. Beddoes repeated the experiment."

Gunther also stated that in 1787 William Higgins acted as operator to Beddoes in the Old Ashmolean Laboratory[11], but he did not give the source of this information, and did not notice that it conflicted with the date, 1788, which he had elsewhere given for Beddoes's "appointment".

The fact that Beddoes was "chemical reader" at Oxford in the spring of 1787 is clear from a memoir published in May, 1787, in which he criticized the state of the Bodleian Library[12]. This was dated "May 31st" on p. 19, but on p. 12 Beddoes said that he was writing in 1787, and on the following page he complained: "I have been for these three months asking for the Journal de Physique for September, 1786. In March last, full four months after it had arrived, the Librarian told me it was in his room in college". Thus Beddoes had been "chemical reader", as he here describes himself, at least as early as the end of February, 1787.

This explains why it was possible for William Higgins to discuss with Beddoes his work on the human calculus, in April, 1787[13], and his observation that ammonia was formed by the action of tin on nitric acid, in June, 1787[14].

It was during the festivities of the vintage, about which (as Stock tells us) he later spoke with much delight, that Beddoes visited Dijon in 1787. Apart from "witnessing the harmless merriment of the peasantry at that joyous season" he made the acquaintance of Guyton de Morveau, who wrote[15] on 20 October, 1787, to his friend P.-L. Baudot: "j'ai eu içi les vacances le ch^{er} Landriani de Milan et le professeur de chymie de l'univ^{té} d'Oxford, M. Beddoes, ils goutent fort la nomenclature et même la doctrine anti-phlogistique".

[11] *Ibid.*, 1937, xi, 279.

[12] *A memorial concerning the state of the Bodleian Library and the conduct of the Principal Librarian. Addressed to the Curators of that Library, by the chemical reader*, n.p., n.d. An account of the contents has been given by E. Robinson, *Ann. Sci.*, 1955, **11**, 137–41, who incorrectly stated (p. 139) that it was written after Beddoes had travelled widely on the Continent.

[13] Wheeler and Partington, *op. cit.*, 36, note 44.

[14] *Ibid.*, 4.

[15] Bibl. Publ. de Dijon, *MS.* 1181, f. 165. Beddoes did not permanently adopt the anti-phlogistic theory.

REVIEWS

The Story of Alchemy and Early Chemistry. By John Maxson Stillman. Pp. xiii + 566. New York: Dover Publications Inc., 1960. Price $2.45.

As stated by the publishers, this book is an unabridged and unaltered republication of the first edition of the work which originally appeared in 1924 under its former title "The Story of Early Chemistry". Professor Stillman (who died on 13 December, 1923, shortly before the arrival of the first proof sheets) was a distinguished contributor of articles to American periodical literature on the chemistry of the 15th and 17th centuries, besides writing a book on Paracelsus that was published in 1920. The present reissue of Professor Stillman's last historical treatise can be highly commended, for the original edition has, presumably, long been out of print; moreover, a general interest in the history of science was not then so well developed as it is today.

In writing his book the author had—to quote the foreword by his late colleague, Professor Stewart W. Young—"planned to develop in parallel from the earliest known beginnings the history, on the one hand of the chemical arts, on the other hand of chemical thought and theory, concluding the work with the downfall of the phlogiston theory. He aimed at a book that should be found readable by those whose knowledge of the science was not profound, as well as by those professional chemists who find little time to delve into such matters for themselves". It can be said at once that he achieved these objectives. And even though later researchers have thrown much fresh light on many aspects in the early history of alchemy and of chemistry, we find in this book a wealth of material, including numerous excerpts from important texts, which provides us with information that cannot readily be found elsewhere. To take but one instance: in the chapter on Lavoisier (chapter 15) we are reminded that the Russian poet and chemist M. W. Lomonosoff [Mikhail Vasilievich Lomonósov, *c.* 1711–1765] repeated (in 1756) Boyle's investigations on the gain in weight of metals when heated in contact with limited amounts of air. Lomonosoff " 'conducted experiments in air-tight sealed glass vessels, to ascertain whether the weight of the metals increases on account of the heat' ". He concluded that Boyle's opinion " 'is false, for without the admission of external air, the weight of the burned metal remains the same' ". Lomonosoff's experiments "were some eighteen years previous to similar demonstrations by Lavoisier. It is in this proof and his rejection of the phlogiston hypothesis as an unnecessary hypothesis that Lomonosoff is a forerunner of Lavoisier".

The subject-matter is divided into 15 chapters ranging in scope from "The Practical Chemistry of the Ancients" to "Lavoisier and the Chemical Revolution". The text is well documented. There is a useful bibliography (14 pages) and a comprehensive general index (12 pages).

The present reprint on good quality paper—albeit a "paper-back"—of Professor Stillman's admirably written and scholarly treatise is a credit to the enterprising publishers, and its modest price in comparison with that of the original edition should attract a wider circle of readers interested in the history of alchemy and of early chemistry.

D. G.

Toward Modern Science. Edited by ROBERT M. PALTER. Volume I. (Studies in Ancient and Medieval Science). Pp. xiv + 270; Volume II. (Studies in Renaissance Science.) Pp. 218. New York: Farrer, Straus and Cudaby, 1961. Price $9.00.

IN these two volumes the editor, Dr. Robert M. Palter, has reprinted, with permission from their original sources of publication, a collection of important essays by well-known authorities illustrative of studies in ancient, medieval, and Renaissance science, that have appeared in various learned journals and other media.

The first volume opens with an informative preface that outlines the general trend of historical research as depicted by the ensuing anthology—which comprises selective papers in the field of mathematics, astronomy, physics, chemistry and alchemy, biology and medicine. These essays "cover a wide range in space and time": from ancient Babylonia (*c.* 1500 B.C.) to the European Renaissance (*c.* A.D. 1400–1600). Whether the general reader will appreciate the compiler's opinion that "the principal advantage of such a collection as this over a single author's 'synthesis' lies in the diversity of approaches, the occasional clash of interpretations, the final sense of vast problems yet unresolved and of countless facts awaiting discovery", must be left to individual criticism. But it is clear that such a delineation of the principal features of Western scientific tradition in its early formative stages, does provide all the apparatus necessary for a more humanistic perception of the fundamentals of scientific interpretations and generalizations; indeed, as Dr. Palter says: "The interest and importance of the history of science today far transcend a mere intellectual curiosity about earlier stages of modern science".

Among the essays that appear in volume I, it is a pleasure to note the inclusion of "The Origins of Greek Alchemy" by F. Sherwood Taylor (reprinted from *Ambix* I, 1937), and "Chemistry in Islam" by E. J. Holmyard (reprinted from *Scientia*, XL, 1926).

The two volumes of this book contain a total of 26 essays, and appended to each volume is a selective bibliography that mainly lists some of the books written by the authors of these essays.

In editing this truly impressive anthology of papers by so many distinguished scholars, Dr. Robert M. Palter, (who is Associate Professor of the Physical Sciences and Chairman of the History and Philosophy of Science Staff at the University of Chicago), has performed a task that must surely merit the discriminating reader's grateful thanks. D. G.

Paracelsus, Registerband zu Sudhoffs Gesamtausgabe: Medizinische, naturwissenschaftliche, philosophische Schriften. (Index-Volume to Sudhoff's edition of the medical, scientific and philosophical writings). Compiled by Martin Müller and edited by R. Blaser. Pp. xii + 281, with portrait of Martin Müller. "Nova Acta Paracelsica" Supplementum, 1960. Basel: Karger Libri, 1961. Price Sw.Frs. 60.

THE significance of Paracelsus in the History of Science and Medicine is still *sub judice*. Ever since he died in 1541 admirers and detractors have kept the controversy alive, and it seems as if every century and indeed each generation has to define its own position on this question. This is easier today as Sudhoff's

critical edition (München, 1922–33) has given us easy access to the sources. Not that it superseded the classical editions by Huser, notably Huser's Quarto of 1589–90. But this has become very rare and even the Huser Folios are difficult to obtain, and costly. As editions, they are unsurpassed, as they were prepared while the spirit of the master was fully alive and influential in the direction of medicine and alchemy into scientific channels. In addition, the Huser editions possess indices that have been invaluable for every worker in the field. The Sudhoff edition, by contrast, lacked a proper index and it was hardly possible to gain full information on individual questions short of a study of all its fourteen volumes. This defect has now been admirably filled by the self-denying labour of the late Martin Müller (1878–1960) of Münich University. Braving the hazards of war and post-war times, and in spite of incidents at which the hard work of years seemed to have been destroyed in a few minutes, Müller had the good fortune to see the Herculean task through, and to co-operate in the preparations for its publication. This was made possible by the Swiss Paracelsus Society, its president Professor Donald Brinkmann, and the editorial assistance of Professor Robert Blaser. It is a great work—indispensable not only for the Paracelsus scholar and reader, but also for the historian of science, of medicine, of philosophy, of theology and indeed of the general culture of the Renaissance. The paucity of errors and omissions that can be detected among the thousands of entries is a remarkable feat. Those that have inevitably crept in are easy to correct and of no significance. There are some 150 references to *alchimia*, more than one page of references to *arcana*, 24 to *athanar*, 32 to *balneum*, 56 to *cachimia*, 70 to *conjunctio*, 27 to *elixir*, 95 to *essentia* and *quinta essentia*,—to select but a few items which should interest the reader of *Ambix*.

This indispensable work of reference is bound to inspire and to facilitate the objective appraisal of a figure whom nobody interested in the history of natural philosophy, medicine and religion can afford to ignore. W. P.*

* [The Editor is indebted to Dr. Walter Pagel for contributing this review.]

PUBLICATIONS RECEIVED

A Bibliography of the Hon. Robert Boyle. By John F. Fulton. Second Edition. Pp. xxvi + 218. Clarendon Press: Oxford University Press, 1961. Price 50s.

* * *

We have been requested to published the following advance notice:

The Xth International Congress of the History of Science will be held in the United States of America, 26th August–2nd September, **1962.** Opening sessions of the Congress will be held at Cornell University, Ithaca, New York, and the concluding sessions will be held at the American Philosophical Society, Philadelphia, Pennsylvania. The President of the Congress is Professor Henry Guerlac of Cornell University. The Secretary of the Congress is Professor C. Doris Hellman.

All inquiries should be addressed to **The Secretary, Xth International Congress of the History of Science,** Cornell University, Ithaca, New York (U.S.A.). Those wishing to receive bulletins concerning the congress are requested to communicate with the Secretary.